

PB-230 698

POLLUTION OF THE INTERSTATE WATERS
OF THE POTOMAC RIVER (WASHINGTON
METROPOLITAN AREA)-DISTRICT OF
COLUMBIA-MARYLAND-VIRGINIA. PRO-
CEEDINGS OF CONFERENCE HELD AT
WASHINGTON, D. C. ON APRIL 2-4, MAY 8, 1969.
VOLUME 1

Federal Water Pollution Control Administration
Washington, D. C.

1969

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VOLUME
1

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CONFERENCE

In the Matter of Pollution of the Interstate Waters
of the Potomac River (Washington Metropolitan Area)
District of Columbia-Maryland-Virginia.

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U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

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: THIRD SESSION :
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: of :
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: CONFERENCE IN THE MATTER OF :
: POLLUTION OF THE INTERSTATE :
: WATERS OF THE POTOMAC RIVER :
: AND ITS TRIBUTARIES :
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: Statler Hilton Hotel :
: Washington, D. C. :
: April 2, 3, 4, and :
: May 8, 1969 :
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the report on the

Third Session of the Conference in the
Matter of Pollution of the Interstate Waters of the Potomac
River and its Tributaries, held at the Congressional Room,
Statler Hilton Hotel, 15th and K Streets, N.W., Washington,
D. C., on April 2, 1969, at 9:30 a.m.

PRESIDING:

*It includes reference to the memorandum
of the Secretary of the Interior, dated 3/24/69,
regarding the proposed amendments to the Federal Water
Pollution Control Act, 1969, which are being
submitted to the Senate for its consideration.*

Hon. Carl L. Klein, Assistant Secretary
of the Interior for Water Quality and
Research, Washington, D. C.

CONFEREES:

Mr. Murray Stein, Assistant Commissioner
for Enforcement, Federal Water Pollution
Control Administration, Department of the
Interior, Washington, D. C.

Eugene T. Jensen, Regional Director,
Middle Atlantic Region, Federal Water
Pollution Control Administration, Depart-
ment of the Interior, Charlottesville,
Virginia

Paul W. McKee, Director, Maryland Depart-
ment of Water Resources, State Office
Building, Annapolis, Maryland

CONFEREES (Continued):

Thomas D. McKewen, Director, Bureau
Resources Protection, Maryland State
Health Department, 2305 N. Charles
Street, Baltimore, Maryland

Carl J. Johnson, Executive Director,
Interstate Commission on the Potomac
River Basin, 1025 Vermont Avenue, N.W.,
Washington, D. C.

David D. Dominick, Commissioner, Federal
Water Pollution Control Administration,
Department of the Interior, Washington,
D. C.

Malcolm Hope, Associate Director, Office
of Environmental Health, D. C. Department
of Public Health, 1875 Connecticut Avenue,
N.W., Washington, D. C.

Norman E. Jackson, Director, D. C. Depart-
ment of Sanitary Engineering, District
Building, Washington, D. C.

A. H. Paessler, Executive Secretary,
Virginia State Water Control Board

CONFEREES (Continued):

W. H. Singleton, Member, Virginia State Water Control Board, 628 Oakland Terrace, Alexandria, Virginia

James B. Coulter, Assistant Commissioner for Environmental Health Services, Maryland Department of Health

George Carley, Assistant Executive Director, Interstate Commission on the Potomac River Basin, 1025 Vermont Avenue, Washington, D. C. (Sat in temporarily for C. S. Johnson)

THOSE IN ATTENDANCE:

Mrs. Emma Abbott, Program Analyst, Federal Water Pollution Control Administration - Enforcement, Department of the Interior, Washington, D. C.

Miss Mary C. Ansbro, Editor, Water in the News, 485 Madison Avenue, New York, New York

George E. Arnstein, Executive Secretary, Conference on Environmental Research, National Association of Sciences - National Research Council, 2101 Constitution Avenue, N. W., Washington, D. C.

THOSE IN ATTENDANCE (Continued):

Audrey F. Ayers, Staff Director, Environmental Projects, League of Women Voters Education Fund, 1200 17th Street, N.W., Washington, D. C.

Keith G. Baker, Administrative Assistant, Congressman William L. Hungate, 439 Cannon Building, Washington, D. C.

A. F. Bartsch, Federal Water Pollution Control Administration, Department of the Interior, Corvallis, Oregon

Edmund Baxter, Consultant, Suite 709, 1028 Connecticut Avenue, Washington, D. C.

Frank A. Bell, Jr., Chesapeake Water Resources Branch, Public Health Service, 12720 Twinbrook Parkway, Rockville, Maryland

Lt. Col. Herbert E. Bell, Staff Bioenvironmental Engineer, Headquarters USAF, AFMSPAP, Washington, D. C.

THOSE IN ATTENDANCE (Continued):

Peter H. Benziger, Assistant to Vice-President, Potomac Electric Power Company, 929 E Street, N.W., Washington, D. C.

Dr. Harold Berkson, Federal Water Pollution Control Administration, Department of the Interior, Washington, D. C.

John S. Bethel, Jr., Senior Vice President, Metcalf and Eddy, Inc., Statler Office Building, Boston, Massachusetts

Coronis Bilmanis, Civil Engineer, Naval Ordnance Station, Indian Head, Maryland

Robert Blum, Consultant, Robert Blum & Associates, 815 Connecticut Avenue, Washington, D. C.

Harry Boswell, Past Chairman, Past General Conference, Interfederation Council, Federal Building, Belcrest Road, Hyattsville, Maryland

Jim Bowyer, PIO, Middle Atlantic Region, Federal Water Pollution Control Administration, Charlottesville, Virginia

THOSE IN ATTENDANCE (Continued):

John V. Brink, Chief, Bureau of Public Health Engineering, District of Columbia Department of Public Health, 801 North Capitol Street, Washington, D. C.

Robert Brewer, Branch Chief - Water Resources Division, Department of Commerce - BDSA, Washington, D. C.

A. T. Brust, Public Relations Manager, Fine Papers Division, Westvaco Corporation, Luke, Maryland

John Bunker, Editor, Outdoor America, Izaak Walton League, 719 13th Street, N.W., Washington, D. C.

O. B. Burns, Water & Air Conservation Administration, Westvaco Corporation, 299 Park Avenue, New York, New York

Lewis W. Cadwallader, Vice-President, Potomac Electric Power Company, Washington, D. C.

THOSE IN ATTENDANCE (Continued):

Walter S. Callahan, Chief, Division of
Bacteriology, D. C. Department of Public
Health, 300 Indiana Avenue, N.W., Washing-
ton, D. C.

John Carroll, 2010 Huntington Avenue,
Alexandria, Virginia

John R. Capper, Natural Resources Planner,
Department Chesapeake Bay Affairs, State
of Maryland, State Office Building,
Annapolis, Maryland

Dumitru D. Carstea, Research Hydrologist,
U. S. Geological Survey, Water Resources
Division, George Washington Building,
Arlington Towers, Arlington, Virginia

William H. Cary, Jr., 9607 Glencrest Lane,
Kensington, Maryland

Grover W. Cook, Enforcement Chief, Middle
Atlantic Region, Federal Water Pollution
Control Administration, Department of the
Interior, 918 Emmet Street, Charlottesville,
Virginia

THOSE IN ATTENDANCE (Continued):

William M. Colony, Director, Planning and
Evaluation Office, Middle Atlantic Region,
Federal Water Pollution Control Administra-
tion, Department of the Interior, 918
Emmet Street, Charlottesville, Virginia

Edmund Couch, Jr., Assistant Chief, Water
Conservation Branch, Office, Chief of Army
Engineers, Room 2027, Building T-7,
Washington, D. C.

Bernard W. Dahl, Research Assistant,
Program Planning and Review, Sanitary
Engineering Department, 412 12th Street,
N.W., Washington, D. C.

Julie D. Danforth, Research Assistant,
Natural Resources Policy Center - G.W.U.,
Room 810, 2100 Pennsylvania Avenue, N.W.
Washington, D. C.

R. V. Davis, Assistant Executive Secretary,
Virginia State Water Control Board, 4010
W. Broad Street, Box 11143, Richmond,
Virginia

THOSE IN ATTENDANCE (Continued):

Stanley E. Degler, Assistant Planning
Officer, BNA Publications, 1231 25th
Street, N.W., Washington, D. C.

Alan L. Dessuff, News Correspondent,
WTOP News, Washington, D. C.

William A. Denson, Public Health Engineer,
Prince Georges County Health Department,
Cheverly, Maryland

J. W. Dixon, Consulting Engineer,
4651 24th Street North, Arlington,
Virginia

F. H. Doe, Jr., Director of Utilities,
Arlington County, Court House Building,
Arlington, Virginia

Betty Dooley, Research Assistant (Repre-
senting Robert Blum), 815 Connecticut
Avenue, N.W., Room 516, Washington, D. C.

Thomas M. Downs, Assistant Attorney General,
State Office Building, Annapolis, Maryland

THOSE IN ATTENDANCE (continued):

Kenneth J. Dunn, Staff Mechanical Engineer,
HQ, HQ COMD, USAF (DEE), Bolling Air Force
Base, Washington, D. C.

Richard J. Durgin, Engineering & Design
Division Engineer (City of Arlington),
P. O. Box 178, Arlington, Virginia

K. Warren Easley, Director, Government
Affairs, Monsanto Company, 1101 17th Street, N.W.
Washington, D. C.

William J. Engle, Civil Engineer, Depart-
ment of the Air Force, HQ USAF (AFOCE-KD),
Bolling Air Force Base, Washington, D. C.

F. H. Farrar, Assistant Director of Field
Services, National Wildlife Federation,
1412 16th Street, N.W., Washington, D. C.

Allan B. Fay, 6116 Overlea Road, Washington,
D. C.

George E. Ferguson, Regional Hydrologist,
U. S. Geological Survey, 318 Washington
Building - Arlington Towers, Arlington,
Virginia

THOSE IN ATTENDANCE (Continued):

C. M. Fesler, Member of the Committee 100
on Federal City, 1100 6th Street, N.W.,
Washington, D. C.

Phineas R. Fiske, Reporter, Washington Post,
1515 L Street, N.W., Washington, D. C.

Rushford K. Fleshman, Jr., Administrator,
Occoquan-Woodbridge Sanitary District,
Prince William County, Box 225, Woodbridge,
Virginia

Mrs. Judson C. French, Assistant Area Di-
rector, National Capitol Area Federation
of Garden Clubs, Inc., 1207 Azalea Drive,
Rockville, Maryland

Keith Fry, Assistant to Vice-President
Air & Water Management, International Paper
Company, 220 East 42nd Street, New York,
New York

Paul V. Freese, Deputy Director, Department
of Sanitary Engineering, District of Colum-
bia, Presidential Building - Room 306,
Washington, D. C.

THOSE IN ATTENDANCE (Continued):

J. Gary Gardner, Director, Office of Operations, Middle Atlantic Region, Federal Water Pollution Control Administration, Department of the Interior, 918 Emmet Street, Charlottesville, Virginia

Lloyd Gebhard, Regional Director, ECA, CPEHS, Public Health Service, Department of Health, Education, and Welfare, Region III, Charlottesville, Virginia

James E. Germain, Vice-President, Roy F. Weston, Inc., 1629 Williams Way, West Chester, Pennsylvania

Marlene Gilbert, State Laws Analyst, Federal Water Pollution Control Administration, Department of the Interior, Washington, D. C.

LTC William F. Gilley, Environmental Pollution Consultant, Office of the Surgeon General, Department of Army, Washington, D. C.

THOSE IN ATTENDANCE (Continued):

Louis A. Gravelle, Commissioner, Washington
Suburban Sanitary Commission, Hamilton
Street, Hyattsville, Maryland

Robert E. Greenfield, National Institutes
of Health, 10112 Parkwood Terrace, Bethesda,
Maryland

Hon. Gilbert Gude, U. S. House of Representa-
tives, Washington, D. C.

M. H. Gula, Chief, Sanitary Division,
Arlington County, Virginia, Court House -
213, Arlington, Virginia

Louis L. Guy, Jr., Civil Engineer, Langley,
McDonald & Overman, P. O. Box 12047,
Norfolk, Virginia

Margery Gverin, Health & Environmental
Protection, C.O.G., 1225 Connecticut
Avenue, N.W., Washington, D. C.

A. W. Hadder, Director, Enforcement Division,
State Water Control Board, P. O. Box 11143,
Richmond, Virginia

THOSE IN ATTENDANCE (Continued):

Harry L. Hale, Director of Public Works,
County of Fairfax, 4000 Chain Bridge Road,
Fairfax, Virginia

L. M. Hale, Agency for International De-
velopment, State Department, 21st Street,
N.W., Washington, D. C.

Robert L. Hall, Associate, Greeley & Hansen,
Consulting Engineers, 14 Jackson Boulevard,
Chicago, Illinois

Jean M. Hansman, Research Associate,
Natural Resources Policy Center, George
Washington University, Washington, D. C.

Robert Harrigan, Vice-President and Branch
Manager, Fisher Science Company, 7722 Fenton
Street, Silver Spring, Maryland

Dr. Jack M. Heinemann, Staff Scientist,
Hazleton Laboratories, TRW, Box 30, Falls
Church, Virginia

Mrs. Elizabeth Hartwell, Chairman, Citizens
Council for a Clean Potomac, 7968 Bolling
Drive, Alexandria, Virginia

THOSE IN ATTENDANCE (Continued):

Mrs. Orris Herfindahl, Member, Conservation
Committee Association (Canoe Cruises),
Canoe Cruises Association, 902 Madison
Lane, Falls Church, Virginia

Dr. Leo J. Hetling, Consultant, formerly
with Federal Water Pollution Control
Administration, New York State Health
Department, Albany, New York

Hon. Lawrence T. Hogan, U. S. Congressman,
5th District - Maryland, 1027 Longworth
House Office Building, Washington, D. C.

Richard C. Hoffmann, Federal Water Pollution
Control Administration, Department of the
Interior, Washington, D. C.

Julian C. Holmes, President, Citizens
Association of Friendly, 8062 Thorne Drive,
Oxon Hill, Maryland

Donald D. Huffman, Civil Engineer, Prince
William County, 425 Lee Avenue, Manassas,
Virginia

THOSE IN ATTENDANCE (Continued):

Miss Mary Lee Hunter, League of Women
Voters, 4201 Cathedral Avenue, N.W.,
Washington, D. C.

J. R. Hyland, Federal Water Pollution
Control Administration, Department of
the Interior, Washington, D. C.

N. A. Jaworski, Sanitary Engineer, Annapolis
Science Center, Chesapeake Technical Sup-
port Laboratory, Annapolis, Maryland

Mrs. E. T. Jensen, 3 Kingston Road,
Charlottesville, Virginia

Allan R. Jones, Legislative Assistant to
Senator William B. Spong, Jr. (Representing
Senator Spong), 5327 New Senate Office
Building, Washington, D. C.

Kenneth M. Karch (P.E.), Environmental
Health Engineer, Metropolitan Washington
Council of Governments, 1225 Connecticut
Avenue, N.W., Washington, D. C.

THOSE IN ATTENDANCE (Continued):

John M. Kauffman, 9 Magnolia Parkway,
Chevy Chase, Maryland

Sally Keel, Legislative Assistant to
Congressman Gude, 226 Cannon House Office
Building, Washington, D. C.

Frazier Kellogg, Cabin John Citizens
Association, 7725 Tomlinson Avenue,
Cabin John, Maryland

T. James Kempton, Pollution Control
Specialist, Virginia State Water Control
Board, P. O. Box 11143, Richmond, Virginia

Walter Kiechel, Jr., Assistant Chief,
General Litigation Section, Land & Natural
Resources Division, U. S. Department of
Justice, Washington, D. C.

Mrs. Margaret Kilpatrick, Press, 3320
P Street, N.W., Washington, D. C.

F. W. Kittrell, Special Consultant, Federal
Water Pollution Control Administration,
Technical Support, 7625 Forest Road,
Cincinnati, Ohio

THOSE IN ATTENDANCE (Continued):

K. L. Kollar, Director, Water Resources
Division, U. S. Department of Commerce,
Room 4111, U.S.D.C., Washington, D. C.

John W. Krasauskas, Chief, Plant Operations
Branch, Corps of Engineers, 5900 MacArthur
Boulevard, N.W., Washington, D. C.

Egil (Bud) Krogh, Staff Assistant to the
Counsel of the President, The White House,
Washington, D. C.

Peter G. Kuh, Staff Assistant A/SQR,
Department of the Interior, Washington,
D. C.

Charles E. Lake, Chief, Maintenance -
Utilities Branch, General Services Adminis-
tration, 7th & D Streets, S.W., Washington,
D. C.

James R. Land, Jr., Project Engineer -
Woodbridge, Langley, McDonald & Overman,
Box 12047, Norfolk, Virginia

THOSE IN ATTENDANCE (Continued):

Everett Lemley, Administrative Officer,
Middle Atlantic Region, Federal Water
Pollution Control Administration, 918
Emmet Street, Charlottesville, Virginia

John J. Lentz, Director, Environmental
Health, Metropolitan Washington Council
of Governments, 1225 Connecticut Avenue,
N.W., Washington, D. C.

Wil Lepkowski, Chemical and Engineering
News, 1155 16th Street, N.W., Washington,
D. C.

Guy E. Lerner, District Engineer, State
of Maryland - Department of Water Resources,
Annapolis, Maryland

Lester H. Levine, Captain, United States
Coast Guard, Captain of the Port, Baltimore,
COTP, Baltimore, Building 70, USCG Yard,
Curtis Bay, Maryland

Jean B. Levesque, Associate Director for
Water Services, Department of Sanitary En-
gineering, D. C. Government, 12th and Penn-
sylvania Avenue, N.W., Washington, D. C.

THOSE IN ATTENDANCE (Continued):

Rosanne Light, Enforcement Analyst, Federal
Water Pollution Control Administration,
Department of the Interior, 1921 Jefferson
Davis Highway, Arlington, Virginia

N. Loe, Director, Washington Yacht Club,
P. O. Box 9083, Washington, D. C.

Norman D. Lowery, Sanitarian, Prince Georges
County Health Department, Cheverly, Maryland

G. Kenneth Lyons, 6725 Towne Lane Road,
McLean, Virginia

Gordon E. McCallum, Vice-President Engineer-
ing Science, 2600 Virginia Avenue, N.W.,
Washington, D. C.

Charles McCarty, Technical Representative,
Hercules, Inc., Wilmington, Delaware

J. H. McCutchen, Sanitary Engineer, Con-
sultant to NPS NC Region, National Park
Service, 1100 Ohio Drive, Washington, D. C.

Edward F. McGinnis, Vice-President, Under-
water Storage, Inc., 1028 Connecticut Avenue,
Washington, D. C.

THOSE IN ATTENDANCE (Continued):

William C. McKay, Marketing Manager,
Ocean Science and Engineering, Inc.,
Del Ray Avenue, 4905, Washington, D. C.

Robert J. McLeod, General Manager and Chief
Engineer, Washington Suburban Sanitary
Commission, Hyattsville, Maryland

Hester P. McNulty, Potomac Basin Inter-
League Committee, League of Women Voters,
Falls Church, Virginia

Kenneth M. MacKenthun, Field Investigations
Branch, U. S. Department of the Interior,
5555 Ridge Avenue, Cincinnati, Ohio

James MacNees, Reporter, Baltimore Sun,
Baltimore, Maryland

Jess W. Malcolm, Executive Director, The
Chesapeake Bay Foundation, P. O. Box 209,
Annapolis, Maryland

Alfred Machis, Deputy Chief Engineer,
Washington Suburban Sanitary Commission,
4017 Hamilton Street, Hyattsville, Mary-
land

THOSE IN ATTENDANCE (Continued):

Mrs. Dean W. Martin, Sr., Federated Womens
Clubs of Prince Georges County, 7121 River-
dale Road, Lanham, Maryland

Robert Martin, Sport Fishing Institute,
719 13th Street, N.W., Washington, D. C.

Thomas P. Meloy, Manager, Environmental
Science Center, Melpar, 7200 Arlington
Boulevard, Falls Church, Virginia

Edward K. Miller, Spl. Reporter, Potomac
Edison Company, Hagerstown, Maryland

Stanton S. Miller, Asst. Editor, Environ-
mental Science and Technology, 1155 16th
Street, N.W., Washington, D. C.

Eugene Minney, National Clean Water Com-
mittee, Izaak Walton League, 228 N. Raymond
Street, Griffith, Indiana

Ilona M. Modly, Res. Asst., Congressman
Hogan's Office, 2116 Bucknell Terrace,
Silver Spring, Maryland

THOSE IN ATTENDANCE (Continued):

Mrs. Samuel V. Moore, Member, Board of Directors, Northern Virginia Conservation Council, 4104 Pineridge Drive, Annandale, Virginia

George J. Moorehead, System Planning Division, Chief, Department of Sanitary Engineering, D. C. Government, 313 Presidential Building, Washington, D. C.

Jonas Morris, Special Representative, Citizen's Permanent Conference on the Potomac River Basin, 206 Georgetown Building, 2233 Wisconsin Avenue, N.W., Washington, D. C.

Michael C. Mulbarger, Engineer In Charge, Manassas Field Station, Federal Water Pollution Control Administration, c/o GMSD, 425 Lee Avenue, Manassas, Virginia

Rebecca H. Nerenberg, Program Analyst, Office of Operations, Federal Water Pollution Control Administration, Department of the Interior, Washington, D. C.

THOSE IN ATTENDANCE (Continued):

David R. Newman, Reporter, McGraw Hill,
Inc., National Press Building, Washington,
D. C.

Sylvester Olson, Director, Division of
Enforcement Program, Federal Water Pollu-
tion Control Administration, Department
of the Interior, Washington, D. C.

Roy L. Orndorff, Acting Executive Secretary,
Potomac River Basin Advisory Committee,
Room 1104, 1025 Vermont Avenue, N.W.,
Washington, D. C.

William C. Overman, Langley, McDonald &
Overman, Consulting Engineers, P. O. Box
12047, Norfolk, Virginia

J. Kelly Paull, Director, Operations Divi-
sion, Department of Public Works, County
of Fairfax, 4000 Chain Bridge Road,
Fairfax, Virginia

Robert R. Perry, Deputy Chief Sanitation,
District of Columbia, 415 12th Street,
N.W., Washington, D. C.

THOSE IN ATTENDANCE (Continued):

Thomas H. Pheiffer, Recreation Resource
Specialist, Bureau of Outdoor Recreation,
Department of the Interior, Washington, D. C.

Robert W. Pierce, Assistant to Chief, Engineer-
ing Division, Maryland Department of Water
Resources, State Office Building, Annapolis,
Maryland

Rheta Piere, Administrative Staff Assistant,
Office of Assistant Commissioner for Enforcement,
Federal Water Pollution Control Administration,
Department of the Interior, Washington, D. C.

Ted Pankowski, Conservation Associate, Izaak
Walton League, Room 509, 719 - 13th Street, N.W.,
Washington, D. C.

Alfred E. Robinson, Jr., Chief Project Investiga-
tion Section, Baltimore District, Corps of
Engineers, Box 1715, Baltimore, Maryland

Ray M. Pitts, Vice President, Ocean Systems,
Inc., Isaak Newton Industrial Square, Reston,
Virginia

THOSE IN ATTENDANCE (Continued):

William F. Roeder, Chief, Sanitation,
Department of Sanitary Engineering,
Presidential Building, 415 12th Street,
N.W., Washington, D. C.

Theodore Rogowski, Assistant Solicitor,
Water Pollution Control, Department of the
Interior Building, Room 6062, Washington,
D. C.

Mrs. Lillian E. Ross, Administrative
Assistant, Office of the Assistant Commis-
sioner of Enforcement, Federal Water
Pollution Control Administration, U. S.
Department of the Interior, Washington,
D. C.

Robert B. Russ, Assistant to Chief Engineer,
Washington Suburban Sanitary Commission,
4017 Hamilton Street
Hyattsville, Maryland

Robert B. Samworth, Chief, Grants, Research,
and Statistics, Department of Sanitary En-
gineers, Government of the District of
Columbia, Washington, D. C.

THOSE IN ATTENDANCE (Continued):

Clair N. Sawyer, Vice-President,
Metcalf & Eddy

Edith Saul, Water Resources Chairman,
League of Women Voters of D. C., 3632
Prospect Street, N.W., Washington, D. C.

Jodie Scheiber, Research Analyst,
Conservation & Natural Resources Sub-
committee, B349C Rayburn House Office
Building, Washington, D. C.

Melvin E. Scheidt, Consultant, Johns
Hopkins University, Baltimore, Maryland

Melvin Leon Schick, Chemist, General Serv-
ices Administration, 7th and D Street, S.W.,
Regional Office Building, Washington, D. C.

A. L. Schmit, Plant Engineer, Minnesota
Mining and Manufacturing Company, P. O.
Box 382, Charles Town, West Virginia

David A. Schuenke, Attorney, U. S. Interior -
Solicitor, Interior Building, Washington,
D. C.

THOSE IN ATTENDANCE (Continued):

Donald E. Schwinn, Sanitary Engineer,
Metcalf & Eddy, Statler Office Building,
Boston, Massachusetts

Harvey L. Segal, Civil Engineer, HQ -
USAF (AFOCE), 4000 Massachusetts Avenue,
N.W. #726, Washington, D. C.

Lucy W. L. Seligson, Program Advisor,
Federal Water Pollution Control Administra-
tion, Department of the Interior, Washington,
D. C.

S. W. Shafer, Engineer, Director, Alexandria
Sanitation Authority, 835 South Payne Street,
Alexandria, Virginia

Mrs. C. F. S. Sharpe, Program Specialist,
Water Resources, League of Women Voters of
the United States, 1200 17th Street, N.W.,
Washington, D. C.

Thomas W. Shives, Chief, Division of Water
and Sewerage, Maryland State Department of
Health, 2305 N. Charles Street, Baltimore,
Maryland

THOSE IN ATTENDANCE (Continued):

A. D. Sidio, Chief, TA&I Branch - Cincinnati,
Federal Water Pollution Control Administra-
tion, Department of the Interior, 5555
Ridge Avenue, Cincinnati, Ohio

Sidney A. Silver, Chief Engineer, Underwater
Storage, Inc., 1028 Connecticut Avenue, N.W.,
Washington, D. C.

Ivan H. Sims, Chairman - Interdivision
Committee on Potomac Basin, Izaak Walton
League of America, 7600 New Market Drive,
Bethesda, Maryland

William H. Singleton, Member, Virginia
State Water Control Board, 628 Oakland
Terrace, Alexandria, Virginia

W. D. Sitman, Vice-President, Roy F. Weston,
Inc., 1426 Lewis Lane, West Chester, Penn-
sylvania

Herbert H. Slaughter, Federal Executive
Institute, Charlottesville, Virginia

THOSE IN ATTENDANCE (Continued):

William Steif, Staff Writer, Scripps -
Howard Newspaper, 1013 13th Street, N.W.,
Washington, D. C.

Henry Stetina, Director, Interstate Compacts
and Uniform State Laws, Enforcement Program,
Federal Water Pollution Control Administra-
tion, Department of the Interior, Washington,
D. C.

Susan C. Stetina, 6003 Conway Road, Bethesda,
Maryland

Arnold Speiser, Chief, Water Quality Control
Division, D. C. Department of Public Health,
801 N. Capitol Street, N.E., Room 733,
Washington, D. C.

L. P. Steuart II, Steuart Petroleum Company,
4646 40th Street, N.W., Washington, D. C.

Jim Strong, Virginia State Water Control
Board, 4014 W. Broad Street, Richmond,
Virginia

THOSE IN ATTENDANCE (Continued):

Lloyd W. Swift, World Wildlife Foundation,
Washington, D. C.

Norris W. Sydnor, Jr., WPC Project Director,
D. C. Government Department of Sanitary
Engineering, Presidential Building - Room
229, 415 12th Street, N.W., Washington,
D. C.

Maurice Tobin, Attorney, Tobin Associates,
Suite 809, 1140 Connecticut Avenue, N.W.,
Washington, D. C.

John Toomer, Engineering Technician,
D. C. Public Health, 801 N. Capitol Street,
N.E., Washington, D. C.

Robert B. Treadway, General Manager, Link
Information Sciences, 2345 S. Ode Street,
Arlington, Virginia

James E. Ure, Associate, Alexander Potter
Associates, 99 Church Street, New York,
New York

THOSE IN ATTENDANCE (Continued):

Bill Nelson Utz, Special Assistant to
U. S. Senator H. F. Byrd, Jr., Virginia,
Room 417, Old Senate Office Building,
Washington, D. C.

V. L. Vasaitis, Sanitary Engineer, Chesapeake Division, Naval Facility Engineering Commission, Washington Navy Yard, Washington, D. C.

David Vaughn, Environmental Engineer,
Resources Research Inc., 1916 Newton Square
West, Reston, Virginia

Dr. Arno Vishoever, Bio-Chemical Engineer,
Civic Congress and Broad Creek Citizens
Association, 1101 Mariner Drive, Oxon Hill,
Maryland

James R. Vincent, Sanitary Engineer, Federal
Water Pollution Control Administration, Department of the Interior, Washington, D. C.

Robert Waldrop, Sierra Club, Representative,
235 Massachusetts Avenue, N.E., Washington,
D. C.

THOSE IN ATTENDANCE (Continued):

Dan M. Watt, Chief, Washington Aqueduct
Division, Corps of Engineers, U. S. Army
Engineer District, Baltimore, Maryland

Edwin C. Weber, District Engineer, State
of Maryland Department of Water Resources,
State Office Building, Annapolis, Maryland

Eugene W. Weber, American Society of Civil
Engineers, 2700 Virginia Avenue, N.W.,
Washington, D. C.

Claude C. Westmoreland, Engineering Techni-
cian, D. C. Department of Public Health,
Water Quality Control Division, 801 N.
Capitol Street, N.E., Washington, D. C.

Dr. Mary Wetzel, Research Biologist, Cabin
John Citizen's Association, 7615 Cabin
Road, Bethesda, Maryland

Cecilia A. Wingfield, Clerk-Typist, Federal
Water Pollution Control Administration,
U. S. Department of the Interior, Washington,
D. C.

THOSE IN ATTENDANCE (Continued):

Captain Jeffery L. Yarne, U. S. Army,
Environmental Health Engineer, First
U. S. Army Surgeon's Office, First U. S.
Army Medical Laboratory, Attention EHES,
Fort George Meade, Maryland

ADDITIONAL ATTENDANCES:

Murray Grant, representing Mayor Walter E.
Washington, Washington, D. C.

David G. Stephan, Acting Assistant Commis-
sioner, Research and Development, Federal
Water Pollution Control Administration,
Department of the Interior, Washington, D.C.

Johan A. Aalto, Federal Water Pollution
Control Administration, Department of the
Interior, Charlottesville, Virginia

Robert Ware Straus, Executive Vice President,
Accokeek Foundation, Inc.

John S. Hewins, Governmental Relations
Coordinator, The Maryland-National Capital
Park and Planning Commission

Stewart Finley, Chairman, Northern Virginia
Soil and Water Conservation District

ADDITIONAL ATTENDANCES (Continued):

Yates M. Barber, Staff Assistant, Assistant
Director - Research, Bureau of Sport
Fisheries and Wildlife, Department of the
Interior

Robert N. Bodine, Jr., Treasurer, Citizens
Council for a Clean Potomac

Franklin J. Price, Regional Planner, Civil
Engineer, Metropolitan Washington Council
of Governments, 1225 Connecticut Avenue,
N. W., Washington, D. C. 20036

John A. Redner, Staff Sanitary Engineer,
U. S. Public Health Service, FDA, RC 310,
200 C Street, S. W., Washington, D. C. 20204

Paul W. Reed, Chief, Office of Program
Planning and Review, D. C. Department of
Sanitary Engineering, 12th and Pennsylvania
Avenue, N. W., Washington, D. C.

J. E. Riley, Assistant to Vice President,
MELPAR, Inc., 7700 Arlington Boulevard,
Falls Church, Virginia 22046

ADDITIONAL ATTENDANCES (Continued):

J. H. Roadcap, Assistant Director, Pollution
Abatement Division, Virginia State Water
Control Board, P. O. Box 11143, Richmond,
Virginia

H. E. Robbins, Executive Secretary, Water
Resources Committee, Manufacturing Chemists
Association, 1825 Connecticut Avenue, N.W.,
Washington, D. C. 20009

Millard H. Robbins, Jr., Director, Pollution
Abatement Division, State Water Control
Board, Box 11143, Richmond, Virginia 23230

Harry Ramineh, Supervisory Civil Engineer,
D.C. Government, Department of Sanitary
Engineers, 12th and Pennsylvania Avenue, N.W.,
Washington, D.C.

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P R O C E E D I N G S

OPENING STATEMENT

BY HONORABLE CARL L. KLEIN
ASSISTANT SECRETARY OF THE INTERIOR
FOR WATER QUALITY AND RESEARCH

SECRETARY KLEIN: Ladies and Gentlemen:

I welcome you to the Potomac River Conference. My name is Carl Klein. I am the Assistant Secretary of the Interior for Water Quality and Research.

The Conferees here with me today are, from the Virginia State Water Control Board, Mr. A. H. Paessler; Mr. Normal Jackson for the District of Columbia Department of Public Health; the Maryland Department of Water Resources will be represented by Mr. Paul W. McKee; the Conferee for the Maryland State Department of Health is Mr. James B. Coulter; and the Interstate Commission on the Potomac River Basin will be represented by Mr. Carl J. Johnson.

The Federal Conferee is Mr. Eugene Jensen of the Federal Water Pollution Control Administration, U. S. Department of the Interior, Middle Atlantic Region.

As a result of conference sessions held in 1957 and 1958 a program of remedial action was established. In brief, this program was as follows:

Opening Statement - Hon. C. L. Klein

1. The District of Columbia accomplish by 1958 disinfection of sewage when necessary and 80% reduction of biochemical oxygen demand (BOD) in sewage reaching the treatment plant, that that degree of reduction be maintained, and that plans for additional treatment as needed be made far enough in advance so that the District plant would not again become a significant source of pollution to the Potomac River.

2. The Virginia communities (Alexandria, Arlington, and Fairfax County) provide treatment commensurate with that of the District.

3. The District implement by 1966, the recommendations of their consulting Board of Engineers (Plan C - except for the Rock Creek interceptor) for control of stormwater overflows.

Now a word about the procedure: The Conferees will be called upon to make statements. The Conferees, in addition, may call upon participants whom they have invited to the conference to make statements. In addition, we shall call on other interested individuals. At the conclusion of each statement, the Conferees will be given an opportunity to comment or ask questions, and I may ask a question or two.

Opening Statement - Hon. C. L. Klein

At the end of all the statements, we shall have a discussion among the Conferees and try to arrive at a basis of agreement on the facts of the situation. Then we shall attempt to summarize the conference orally, giving the Conferees, of course, the right to amend or modify the summary.

Under the Federal law, the Secretary of the Interior is required at the conclusion of the conference to prepare a summary of it which will be sent to the Conferees. The summary, according to law, must include the following points:

1. Occurrence of pollution of interstate waters subject to abatement under the Federal Act;
2. Adequacy of measures taken toward abatement of pollution; and
3. Nature of delays, if any, being encountered in abating the pollution.

The Secretary is also required to make recommendations for remedial action if such recommendations are indicated.

We are having a verbatim transcript of the conference being made by Mr. Al Zimmer. This is to make sure that we have everybody's statement exact, and also so

Opening Statement - Hon. C. L. Klein

that we can prepare a summary. It usually takes about three or four months for the transcript to come out in printed form. I assure you I will try to cut this time down. If you wish a record beforehand, you can check with the reporter and make your own arrangements with him.

If we have color items, they will not appear as color items in the transcript but in black and white. So please, while you are talking here, remember that if you refer to colors on a map or chart it will not come out in color in the final transcript.

We shall make copies of the summary and transcript available to the official State and interstate water pollution control agencies. We find that for the purpose of maintaining relationships within the States the people who wish summaries and transcripts should request them through their State agencies rather than come directly to the Federal Government. This has worked successfully in the past and we intend to stay with this chain of command.

I would suggest that all speakers and participants other than the Conferees making statements come to the lectern and identify themselves for purposes of the record, if you have anything to say on this matter.

Opening Statement - Hon. C. L. Klein

One of the things I shall try to do is keep this conference on schedule. It is my opinion that we should have started at 9:30, and we started a few minutes late. I would hope that at 12:00 noon sharp, we can wind up and come back again at 1:30 this afternoon, and I hope that we shall be able to proceed on this schedule.

At this time, representing the Secretary of the Interior to give the official opening address, I give you the Under Secretary of the Interior, the Honorable Russell Train.

STATEMENT OF THE HONORABLE
THE SECRETARY OF THE INTERIOR

WALTER J. HICKEL

READ BY

HONORABLE RUSSELL TRAIN

MR. TRAIN: I didn't know that this was an official address. It is entitled "Remarks."

Mr. Chairman and participants in this enforcement conference on the Potomac:

I see many old friends in this room, fellow veterans, if I may, of the Battle of the Potomac.

Secretary Hickel regrets very much that a

Hon. W. J. Hickel

last minute change in plans has made it impossible for him to be here, and he has asked me to give you his regrets and his greetings.

I personally am glad that he had a change in plans, because I have had a long standing interest in the Potomac. I grew up here myself. I have been a participant with you in some of the previous struggles, and so I feel a very keen interest in this whole problem.

The lower Potomac River -- Washington, D. C.'s river -- is, to put it bluntly, a national disgrace. It is grossly polluted. It is a shocking example of man's mistreatment of a natural resource.

That is why we are here today.

Our punishment of the Potomac River represents a mistake that should be corrected as quickly as possible. I would hope that means something before the year 2000.

And there are many Potomacs across the land.

Fortunately, the American people are developing an environmental conscience. They are tired of being confronted at every turn by unnecessary environmental abuse.

The scars which are the legacy of environ-

Hon. W. J. Hickel

mental non-management and mismanagement are nowhere more obvious than in America's waterways -- and here in the murky, brown band of the lower Potomac.

This river, more than any other, is an historic part of our American tradition.

George Washington loved this river.

Indeed, every President since Washington has walked along its banks.

Today, as it flows by the Nation's Capital, the Potomac bears a burden of wastes from millions of people, their industries, farms and cities.

So the people of this Nation are particularly concerned that this river be cleaned and protected.

The representatives here today from the District of Columbia, the Maryland and Virginia State governments, and the Federal Government have a task for all the Nation.

Your task is to come up with a strong action program to clean up the lower Potomac and its tributaries -- this means a 26 mile sweep of the river from Little Falls to Hallowing Point, including the Anacostia River, Rock Creek and other tributaries.

We are here today -- to put it quite

Hon. W. J. Hickel

simply -- because the recommendations for corrective action approved by the conferences in 1957 and 1958 have not been fulfilled.

This session of the conference will consider a report issued last month by Secretary Hickel -- a report showing how the Potomac River and its tributaries in the Washington area could be cleaned up for a cost of upwards of \$500 million.

The report was prepared by Interior's Federal Water Pollution Control Administration.

It makes six specific recommendations -- four of which are aimed at keeping virtually all organic wastes and phosphates from reaching the river. A fifth recommendation deals with silt control; a sixth, with keeping the banks of the river and its tributaries free of junk and debris.

At the heart of the pollution problem confronting the lower Potomac -- and other reaches of the river as well -- is population expansion. Last year the Department of the Interior published a report on the Potomac, entitled "The Nation's River." The report said that the Potomac River Basin suffered sorely from the "people" problem -- the ever increasing pressure of ever increasing

Hon. W. J. Hickel

numbers of people on the environment.

I have said many times that we do not have too many people. The problem is that they are too concentrated in a few places.

From an estimated 3 million persons next year, the population of the Washington Metropolitan Area is expected to climb to nearly 9 million by the year 2000.

We must move ahead now, knowing that we will have to run very fast to get ahead of this complex problem.

Delay is the friend of pollution. Using today's best knowledge, we must attack the Potomac's pollution with a view to tomorrow's needs. We have lagged too long and we are a decade or a generation behind in applying solutions to yesterday's problems. Meanwhile, today passes and tomorrow lies ahead.

As this conference opens, I pledge you my fullest support and that of the Secretary. We wish you every success.

I know you will develop a realistic program to make the Potomac a national river in the truest sense.

Thank you very much.

Mr. Chairman, I hope that you are now back

Hon. W. J. Hickel

on schedule.

SECRETARY KLEIN: Thank you very much.

I usually introduce the head table first, but a good many people were not in the room yet, and while I told you who the Conferees were, I would like now to introduce the head table to you as I think the audience now is practically complete.

On my left and your right, Mr. W. H. Singleton of the Virginia State Water Control Board. Please do not applaud. Mr. Singleton.

Next to Mr. Singleton, Mr. A. H. Paessler, who is the Executive Secretary of the State Water Control Board of Virginia.

This is Mr. Norman E. Jackson, Director of the D. C. Department of Sanitary Engineering.

Next to Mr. Jackson, Mr. Malcolm Hope, Associate Director, Office of Environmental Health, D. C. Department of Public Health.

Mr. Murray Stein, Assistant Commissioner for Enforcement, Federal Water Pollution Control Administration.

On my right, we will start with Mr. Paul W. McKee, Director of the Department of Water Resources of the State of Maryland.

Next to Mr. McKee, Mr. Thomas D. McKewen,
Director, Bureau of Resource Protection, Maryland State
Health Department.

Mr. Carl J. Johnson, Executive Director,
Interstate Commission on the Potomac River Basin.

Next to him, we have Mr. Eugene T. Jensen,
who is the Federal Water Pollution Control Administration
representative for this region.

The empty chair on my right would ordinarily
have in it Mr. David D. Dominick, Commissioner of the Fed-
eral Water Pollution Control Administration, but this
morning he is attending a briefing by the Corps of Engineers
on the question of dumping of dredgings into the Great
Lakes of this wonderful country of ours.

I may say that if any of you have any
statements, I would ask you to turn the statement in to
the court reporter so that he may include them properly
in the record.

Mr. Stein, do you have a copy of the call
bringing this conference to order?

MR. STEIN: Yes, we do.

SECRETARY KLEIN: Would you please put it
into the record?

MR. STEIN: Thank you, Mr. Chairman.

(The following constitutes the Call of
the Conference.)

UNITED STATES
DEPARTMENT OF THE INTERIOR
OFFICE OF THE SECRETARY
WASHINGTON, D. C. 20240

Jan. 17, 1969

MEMORANDUM

TO: The Secretary

FROM: Assistant Secretary
Water Quality and Research

SUBJECT: Conference on Pollution of the Interstate Waters
of the Potomac River, Washington Metropolitan
Area (District of Columbia-Maryland-Virginia)--
Notice of Conference--Third Session

A. BACKGROUND

The first and second sessions of the Potomac enforcement conference were held August 22, 1957, and February 13, 1958. It had been called by the Surgeon General, U. S. Public Health Service, Department of Health, Education, and Welfare, on the basis of reports, surveys, or studies which showed that health or welfare was adversely affected in States other than those in which the pollutorial discharges

originated.

As a result of the conference discussions, the following remedial action was recommended by the Federal and State conferees:

1. The District of Columbia accomplish by 1958 disinfection of sewage when necessary and 80% reduction of biochemical oxygen demand (BOD) in sewage reaching the treatment plant; that this degree of reduction be maintained; and, that plans for additional treatment as needed be made far enough in advance so that the District plant would not again become a significant source of pollution to the Potomac River.
2. The Virginia communities (Alexandria, Arlington, and Fairfax County) provide treatment commensurate with that of the District.
3. The District implement, by 1966, the recommendations of its consulting Board of Engineers for control of stormwater overflows.

Some progress has been made toward compliance with the conferee's recommendations. Six of the nine sewage treatment plants in the conference area have met the recommendation that 80% BOD removal be accomplished. However, the plants of the District of Columbia, Alexandria, and Fairfax County

failed to meet the conferees' recommendations and these three plants currently account for 94% of the BOD load discharged to the Potomac. Additionally, the recommendation for effective disinfection of treated discharges was not carried out. The District has implemented much of the plan for controlling raw sewage discharges, but did not meet the recommended completion deadline of 1966. Separation of combined storm and sanitary sewers, which accounts for over 22% of the total discharge, is not scheduled for completion before the year 2000. Due to inadequate sewage treatment, the Potomac estuary in the Washington Metropolitan Area remains grossly polluted.

The Department of the Interior report, "The Nation's River," submitted in response to President Johnson's request of February 8, 1965, sets forth a thorough action plan for protecting the whole Potomac River (Tab B). One of the recommendations on Page 108, urges, "Immediate reconvening of the 1957 Enforcement Conference on the Potomac to focus attention on the timetables for controlling pollution in the estuary in the light of water quality standards and also to consider problems of agricultural pollution, sediment, nutrients, dredging, and vessels wastes."

The FWPCA staff recently completed a new survey and report

on the river (Tab C). The Federal report shows continued degraded water quality and recommends measures for combatting many aspects of the problem. The staff recommends a third session of the conference in order to consider necessary remedial actions.

B. WATER QUALITY STANDARDS

Standards for Maryland and the District have been approved and are fairly compatible. Virginia's have not been approved but in the conference area are relevant to the Potomac only as far as Virginia tributaries are concerned. The District has proposed stricter criteria which will match Maryland's more closely on dissolved oxygen, temperature, and fecal coliform counts. The revised criteria are expected to be submitted shortly.

C. RECOMMENDATION

That you sign the enclosed letters to the water pollution control agencies of the District of Columbia, Maryland, and Virginia and the Interstate Commission on the Potomac River Basin, calling the third session of the conference in the matter of pollution of the interstate waters of the Potomac River and its tributaries, Washington Metropolitan Area (Tab A) on April 2, 1969, at the Statler

Hilton Hotel, Washington, D. C.

/s/ Max
Max N. Edwards

Enclosures

* * * *

January 18, 1969

Dear Mr. Paessler:

Under the provisions of the Federal Water Pollution Control Act (33 U.S.C. 466 et seq.) the first and second sessions of the conference in the matter of pollution of the interstate waters of the Potomac River, Washington Metropolitan Area, were called by the Surgeon General, U. S. Public Health Service, Department of Health, Education, and Welfare, and were held on August 22, 1957, and February 13, 1958. In accordance with section 10 of the Federal Water Pollution Control Act, as amended, I hereby call the third session of the Potomac River conference. The conference will convene on April 2, 1969, at 9:30 a.m. at the Congressional Room, Statler Hilton Hotel, 16th and K Streets, N.W., Washington, D. C. I have designated Mr. Murray Stein, U. S. Department of the Interior, as chairman of the conference.

The parties to the conference are the District of Columbia Department of Public Health, the Virginia State Water Control Board, the Maryland State Department of Health, the Maryland State Department of Water Resources, the Interstate Commission on the Potomac River Basin, and the U. S. Department of the Interior.

Participation in the conference will be open to representatives and invitees of these agencies and such interested individuals as make known to the conference chairman their desire to present statements.

The conference will cover the Potomac River and its tributaries in the Washington Metropolitan Area from Little Falls to Hallowing Point. As specified in the Federal Water Pollution Control Act, as amended, we shall furnish a summary of the conference discussions to your Board.

Sincerely yours,

(sgd) Stewart L. Udall
Secretary of the Interior

Mr. A. H. Paessler
Executive Secretary
State Water Control Board
P. O. Box 11143
Richmond, Virginia 23230

* * * * *

Senator W. B. Spong, Jr.

SECRETARY KLEIN: We have a statement for the record from Senator Spong, by Mr. Allan R. Jones.

Mr. Jones, did you want to make that verbally, or just turn it in?

MR. JONES: I will just hand it in and not take up the time.

SECRETARY KLEIN: All right. We know that this is important. Is there anything important that you would wish to call to our attention?

MR. JONES: Senator Spong has made a general statement on the need for doing something about the Potomac. I will be pleased to read it, if you would like.

SECRETARY KLEIN: No. That's quite all right. Unless you are prepared to do so, I won't call on you. If you wish, we would be glad to have you read the statement.

MR. JONES: I will read it.

SECRETARY KLEIN: Fine.

MR. JONES: On behalf of Senator Spong, I want to convey to you his regrets at not being able to be here, but he had a previous commitment this morning.

His statement is as follows:

Senator W. B. Spong, Jr.

STATEMENT OF
THE HONORABLE WILLIAM B. SPONG, JR.,
U. S. SENATE, WASHINGTON, D. C.

READ BY
MR. ALLAN R. JONES

The report of the Department of the Interior on the status of water quality in the Potomac River estuary focuses new attention on the growing awareness that our environment has a limited capacity to assimilate the waste materials generated by man.

The need for a coordinated approach to attack pollution in the Potomac is clearly brought out in the document, and I hope the conference convening today will lead to the development of a strategy to achieve that purpose. The steady deterioration of the river long has detracted from the beauty of the Nation's Capital. The Potomac should be a model of scenic and recreational values.

The phenomenal population growth in Metropolitan Washington since the end of World War II has attracted attention to other more dramatic problems -- transportation, housing, schools and social welfare. Huge public expenditures have been necessary in these critical areas. The scope of these needs in Metropolitan Washington are borne out by the fact that its population increased by 172 per

Senator W. B. Spong, Jr.

cent between 1940 and 1968, compared to 32 per cent nationwide.

The area's present population has been estimated at 2 3/4 million, and as recently as 1965, it was assumed the figure would range between 4 and 6 million by the year 2000. However, I have been informed by the Metropolitan Washington Council of Governments that if the current trend continues, a more probable figure is 7.7 million.

Meanwhile, the condition of the Potomac has steadily deteriorated under the pollution burden resulting from the growing population. Despite abatement advances subsequent to the first and second pollution conferences more than a decade ago, and notwithstanding the expenditure of \$165 million for construction of treatment facilities, the Potomac estuary remains grossly polluted.

A long-range, cooperative attack on the problem is clearly required at the local, State and Federal levels. The estimated cost of abating pollution in the river is substantial. In future planning it should be recognized that the Federal Government, as the largest land owner and employer in the metropolitan area, should

Senator W. B. Spong, Jr.

bear its proportionate share of the cost.

Congress recognized the need for improved sewage treatment facilities when it authorized appropriations for construction grants of \$700,000,000 in fiscal 1969, \$1,000,000,000 in 1970 and \$1,250,000,000 in 1971. Unfortunately, because of budget constrictions made necessary by our involvement in Vietnam, actual appropriations have fallen far short of the authorizations.

For the current year alone, the appropriation for grants was \$486 million less than the authorization. Congressional committees have received testimony on methods of supplementing funds appropriated for grants, but to date no acceptable approach has been found. There is no question that the need for additional funding is imperative.

* * * *

MR. JONES: Thank you very much, Mr. Chairman.

SECRETARY KLEIN: Thank you.

I understand that Congressman Gilbert Gude is in the audience. I would like to call on him now for his statement.

Congressman G. Gude

STATEMENT OF
THE HONORABLE GILBERT GUDE,
U. S. HOUSE OF REPRESENTATIVES
WASHINGTON, D. C.

CONGRESSMAN GUDE: I will have copies of this statement available for all the members shortly.

Mr. Chairman, distinguished guests, knowledgeable witnesses, and conferees:

It is a pleasure and a privilege for me to have this opportunity to address this Conference on Pollution of the Potomac River. As a suburban Maryland Congressman whose District borders the Potomac shores, my interest in this river has been one of long standing and one which I have actively pursued. Thus it is that I have looked forward to this conference with great expectation: the problems which confront us in instituting the best water pollution controls possible and the time limits within which we must work if the goals are to have their greatest impact make this type of conference not only a necessity but a sign of encouragement. I therefore wish to lend my support to the activities and deliberations which will transpire here today and during the next few days, and to applaud the efforts which hopefully will result in enlarged, improved, and more energetic attempts at pollution control.

Congressman G. Gude

Your deliberations over the next several days will expose the intricate details of the pollution problem: the inadequacies of existing sewage disposal facilities; the increasing amounts of silt and sediment which choke the riverway; the unacceptable increases in waste densities, waste, loads, and waste types; the urgent need for phosphorus reduction facilities in order to prevent excessive algal growths; the blatantly improper uses of the shorelines which create and intensify the extent of pollution; the careless, often presumptuous uses of waters which are in the upper regions of a river to the subsequent considerable detriment of waters in the lower regions. The precise nature of these problems and their related variations I must leave to the engineers and technicians to whose expertise I defer.

We have a strong mandate to improve the Potomac. The fact that it borders the Nation's Capitol, the fact that it touches in addition three States and its shorelines meet urban centers and rural fields alike, the fact that it has a lively history running as far back as a 1608 voyage by Captain John Smith who sought to assess its treasures and become acquainted with its features -- all these things lend prestige and a rationale to what we

are trying to do with regard to the Potomac's pollution level. But I will not yield to the temptation of addressing myself to these issues either this morning.

I would make no attempt to imagine or discuss the future of the River, other than in general terms: I cannot accurately predict the timetable to which we must submit in order to avert major problems; nor can I realistically suggest the specific forms of control which would be most effective over the next decade or longer; I hesitate to describe what the full measure of disaster would be if we were to fail to clean up this waterway. In each case, while I could make an educated guess as to what would be involved, I would again have to defer to the knowledge of technicians in order to receive a specific, specialized understanding.

There are two areas to which I wish to address myself this morning. Both cast the pollution problem of the Potomac in a legislative light and both bespeak the need for immediate action.

First, insofar as existing Federal legislation is concerned, there seems to be no real problem with getting Congress to authorize the necessary funds to combat pollution. The Water Quality Act of 1965 required

Congressman G. Gude

that purity standards be established and enforced for interstate waters and the Federal Government was given the power to do this if the States did not.

In 1966, legislation was enacted which authorized substantial amounts of money to help communities pay the costs of abiding by those standards and provided financial incentives for States to establish purity standards on intrastate waters. This 1966 legislation was entitled the "Clean Waters Restoration Act" and has been acknowledged by many as the most significant legislation in history relating to water pollution. In that Act, appropriations were authorized totaling \$3.5 billion during fiscal years 1967-1971 for construction of sewage treatment plants. In addition it provided that a Federal grant could pay for 30%, 40% or 50% of the cost of such sewage treatment facilities, the 40% and 50% grants being conditional on State participation in the financing of the plants and the 50% grant also requiring the establishment by the State of water quality standards for bodies of water located within its boundaries. This Act also authorized funds for research and planning, and vested in the Interior Secretary new investigative powers for use at pollution abatement conferences or hearings.

Congressman G. Gude

A bill passed in late July 1968, appropriated about \$275 million in funds for the Federal Water Pollution Control Administration, and in his budget request for FY 1969, President Johnson requested \$225 million -- an increase of only \$22 million over that amount appropriated in FY 1968 for sewage treatment plant construction grants. Congress had originally authorized \$700 million for FY 1969.

My point in bringing this data to the fore is to suggest that while Congress has been generous in assessing the financial needs of an effective water pollution program, it has been considerably slower in the actual appropriation of needed funds. And I would submit that we need to do some close checking, first, to discern the precise extent of the disparity between funds authorized and the funds actually granted, and, second, to learn the root cause for such inconsistencies, and, third, to press the Congress to come through on its promise of cold, hard cash.

I think this disparity is poignantly illustrated by the situation in Maryland. The State Legislature of Maryland has authorized a \$176 million debt over the past ten years for water pollution expenses, \$150 million of which has been in the past two years. One reason

Congressman G. Gude

for the enormity of these debt amounts is because the Federal Government has not come through with a proportionately great enough share. Maryland will not, and cannot be expected to, continue to appropriate such large amounts, and yet it is that type of sizable funding which is required if the job is to be done.

No one can deny that the enormity of the water clean-up task requires commensurately large appropriations. Therefore, to the extent that we are not using all the available sources or that we are in fact not being granted all that has been authorized to this cause, we are under a burden to intensify our efforts at overcoming these deficiencies. That is Point Number One that I wish to make.

Point Number Two is that through a variety of techniques the water pollution movement has received remarkable public interest and support. My office is continually being requested to send information on this problem to a variety of recipients: likewise, my speech docket requires me to address this issue in a large percentage of my public appearances. But I have been amazed at the number of people who, despite their enthusiasm and support of these efforts at pollution control and abatement,

still lack a basic understanding of the problems involved, and particularly the funds necessary.

For instance, too often water pollution programs are given an enthusiastic send-off by a community, only to be subsequently delayed, impeded and sometimes even halted because certain groups objected to every proposal for sewer treatment facilities sites. This is not to say that such matters should escape public expressions of opinion, but we are hard-pressed to justify such a right when it results in a correlative denial of public health protection when the pollution project is thrown to the wind.

Two levels of public understanding must be reached in the instituting of water pollution control projects: 1) We must strive to secure public acceptance of the fact that if there is to be an effective water pollution control project, there must be sewage disposal facilities and the like placed somewhere in the area. 2) The public must be urged to understand and accept that in water control, as in so many other things, you get what you pay for. Thus, when standards are set by the community, the people of that community must realize that there exists a definite benefit-cost ratio, and the higher the standards,

Congressman G. Gude

the more it will cost to put them into effect. And so we are called upon to assess in money terms just how much we want clean water. This is sometimes a hard thing to understand and accept.

In conclusion, then, I would remind you that the needs and problems surrounding water pollution are multiplying daily. We are under a strong mandate to work to alleviate these evils and it is from this perspective that the work of this conference takes its real meaning. The ideas I have brought to you today are aimed at illustrating means by which the efforts at water control can be improved and advanced. I thank you for this opportunity to appear before you, and wish you well in your undertakings here together.

Thank you.

SECRETARY KLEIN: Thank you very much, Congressman Gude, and, if you would, please have copies for us and for the press.

CONGRESSMAN GUDE: Yes, sir.

SECRETARY KLEIN: We would appreciate it.

Thank you.

Congressman Ichord has asked to make a statement. He is from Missouri, but he lives here. He

Congressman R. H. Ichord

had been in an airplane accident last evening. He has left a transcript of his testimony with us. It is only two pages, and I will ask Mr. Jensen to read it into the record.

MR. JENSEN: We understand that the aircraft was entirely demolished, but, fortunately, the Congressman was not seriously injured.

The statement reads as follows:

STATEMENT OF
HONORABLE RICHARD H. ICHORD
MEMBER OF CONGRESS
EIGHTH CONGRESSIONAL DISTRICT
STATE OF MISSOURI

I live on Swan Creek, across the Potomac River from the home of our first President. Bordering Swan Creek and the Potomac is Fort Washington National Park. To the south, across Piscataway Bay, is our new Piscataway Park.

I am acutely aware of my good fortune to live in this historic area that enjoys the protection of neighboring Federal land acquisition. But I have also learned that the beauty of the Potomac shoreline has been

Congressman R. H. Ichord

preserved, not only by the purchase of land by Congress, but by the dedicated and tireless efforts of the local people who have year after year protected neighboring lands from the devastation of uncontrolled development.

Over the last two centuries, the pioneering aspirations that established colonial America have expanded to new frontiers that now reach beyond the moon and the planets. And I think that the American people today are as enthusiastic about extra-terrestrial exploration as our forefathers were committed to exploring and settling the Great West.

On the other hand, people are affected today by their own earthly environment just as they were 200 years ago. But in some ways, the environment today is more hostile.

I speak of the decimation of natural resources and wildlife, the desecration of our landscapes, and the poisoning of our waterways. These problems are the very reason for this Conference on the Potomac.

To make any headway against the increasing pollution generated by modern civilization, there must be agreement to enforce with total impartiality those few regulations we have. Concurrently, we must support vigorous

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research to develop a modern technology to cope with pollution.

I think that the current controversy over the Piscataway Sewage Treatment Plant is illustrative of the state of the art. The resentment toward this facility shown by local residents indicates ineffective enforcement of pollution regulations. The fact that this brand new plant is in fact incapable of meeting modern requirements for effluent purity dramatizes the need for space-age pollution research.

Let us hope that this Conference will drag us from our lethargy and open our eyes to the disastrous consequences of the ever-increasing pollution of our environment. To modernize pollution control will cost money. But so does hospital care, medicine, and medical research. I think that the American people will find that the cost of developing effective pollution control is a sound investment indeed.

Thank you.

* * * * *

SECRETARY KLEIN: Thank you, Mr. Jensen.

The tone and tenor of this conference has

now been set by the address of Undersecretary Train, and the addresses of Senator Spong, Congressman Gude and Congressman Ichord.

The call now to us is for investigation of the pollution factors, the present abatement factors, and the projection of the problems and answers into the future.

At this time I would like to call on Dr. Jack Lentz, Director of Environmental Health, Metropolitan Washington Council of Governments.

To all the speakers again, if you only have one copy, will you please turn it in to Mr. Peter Kuh from my office, and he will make copies of it for the press, for the reporter and for the conferees.

DR. LENTZ: Mr. Chairman, we certainly can make a copy available.

SECRETARY KLEIN: Fine. Thank you.

DR. LENTZ: I would like to beg your indulgence to provide it to him after the noon hour today, so that we may make copies for our own files.

SECRETARY KLEIN: Please.

DR. LENTZ: All right.

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STATEMENT OF

JOHN J. LENTZ

DIRECTOR, ENVIRONMENTAL HEALTH

METROPOLITAN WASHINGTON COUNCIL OF GOVERNMENTS

DR. LENTZ: Mr. Chairman, Congressman Gude,
Distinguished Guests:

I had anticipated being on the program a little bit later in the afternoon. We have two beautiful exhibits which will be coming over sometime after lunch. We can make them available around the side of the hall. They describe the expected population changes which are likely to occur over the next 30 years or more.

To a large degree, the material which I am going to present to the conference at the present time has already been presented by the three speakers who preceded me, or -- I beg your pardon -- four speakers. Undersecretary Train, Congressman Gude, the representative from Senator Spong's office -- they have all touched on the increasingly urgent problem of expanding population in the Washington Metropolitan Area and the loads that this increasing population are likely to impose on the region.

I would like to very briefly go over in

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some detail what these population loads are likely to be and what the Council of Governments uses as the elements of the problem.

The Council of Governments, just by way of introduction, is a voluntary, non-profit corporation whose membership consists of the members of the governing bodies of the 15 major local jurisdictions, together with all members of Congress and State legislators of the metropolitan Washington area.

The Council of Governments is concerned with a broad spectrum of governmental issues including environmental health, social services, public safety, land use, transportation and comprehensive planning. Functional types of planning currently **under way** at the Council of Governments include transportation, open space, air facilities, and water and sewerage facilities planning. As major support activities to these efforts, the Council of Governments places emphasis on metropolitan area data collection and processing, economic research, population and housing research, and fiscal studies.

COG's Interest in Water and Sewer Problems in the Metropolitan Area

On July 10, 1969, COG took the first step

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into this area by incorporating the Regional Sanitary Advisory Board as a major technical arm of the Council of Governments. This Board includes sanitary engineers, public health officers and other officials from the area governments and their sewer and water authorities. The primary purpose of the Board is the promotion of coordinated planning, operation and construction of facilities for water supply and sewage disposal in the metropolitan area.

COG's technical work program began in 1962 with a consultant study of sanitary sewers and wastewater disposal in the Washington area -- by Drs. Abel Wolman and John C. Geyer, consulting engineers.

In 1963, an officer of the U. S. Public Health Service was detailed to the Council of Governments on a full-time basis to work on air pollution, water supply and water pollution problems.

In 1966 COG established a Department of Environmental Health and hired its own full-time Director.

During 1966, 1967 and 1968 COG sponsored a study of potential sources of future water supply for the metropolitan Washington area.

Also during this time COG has prepared a

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preliminary water and sewerage facilities plan and program for the Washington metropolitan area -- which is currently being reviewed.

Population of Washington Metropolitan Area

A. Brief history

1. The Washington metropolitan area has been one of the fastest growing urban areas in the Nation for the past 28 years.
 - a. Between 1940 and 1968, the Nation's population increased approximately 32 percent while metropolitan Washington's population gain was about 172 percent.
 - b. Moreover, since 1960 the Washington metropolitan area's population has grown at an increasingly faster rate than the Nation as a whole.
 - c. In 1950 the Washington metropolitan area was the eleventh largest in the Nation.
 - d. By 1965, metropolitan Washington ranked eighth among the 224 metropolitan areas in the country.

B. Today

1. As of January 1, 1968, the metropolitan population was estimated to be 2,750,000.

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2. In only one year (1970) the population will stand at the 3 million mark.
 - a. 1.2 million people will live in the Maryland suburbs of Montgomery and Prince George's Counties.
 - b. Almost 1 million people (964,000) are expected to be living in the Virginia suburbs, with almost half living in Fairfax County.
 - c. The remainder -- 814,000 -- will be living in the District of Columbia.

C. The Future

1. Metropolitan Washington stands on the verge of an even greater growth in population than has been seen in the past decade. Washington can look forward to very rapid growth for the remainder of this century -- more rapid, on the average, than for most other urban areas of the United States.
 - a. As recently as 1965, it was assumed that by the year 2000 -- just 31 years away -- the metropolitan area's population would stand somewhere between 4 and 6 million people.
 - b. This would mean an increase of between approximately 33% and 100% over the current population.

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- c. This range of projected population was based upon the results of an economic base study conducted under contract with the National Capital Regional Planning Council -- the Council of Governments' forerunner as the metropolitan planning agency in the Washington area.
 - d. As a working rule of thumb, it was assumed that a population figure of 5 million people in the metropolitan area was reasonable by the year 2000. This represented a 66% increase over the current population.
2. However, in 1968 -- just three years after NCRPC released its population projections, COG became concerned that the area might be growing faster than had been anticipated. To determine this, the Council of Governments commissioned a follow-up study which would not only update the NCRPC population research but which would also help the Council of Governments to establish a methodology for periodically checking on the growth rate of the metropolitan area. The results are just available and are undergoing technical review

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at the moment. However, even though these results are still under review, we must consider that the results are staggering. Consider these findings:

- a. The growth rate of the metropolitan area remained at a relatively constant rate of increase of 3.8 percent per year from 1950 - 1960. However, from 1960 to 1967, the rate of increase rose to 4.6 percent annually.
- b. If current trends continue, our consultants tell us that the metropolitan Washington population will stand somewhere between 6.7 million and 8.9 million by the year 2000.
- c. They say that the most probable figure is 7.7 million by that time.
- d. This is over half again greater than the previous "most probable" figure of 5 million used since 1965.
- e. It also represents a staggering 157% increase from the anticipated population of 3 million people in 1970!
- f. In graphic terms, this means that each year we will add 100,000 more people to our area; this is equivalent to adding a city the size of

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Wilmington, North Carolina to the Washington area each year.

- g. By the year 2000, the Washington metropolitan area is expected to have or could have more people than either Chicago or Los Angeles has today.

7.7 Million People: Where Will They Live?

These projections of population are even more staggering when you look at them at the individual jurisdiction level.

- A. By the year 2000 there will be some 3.6 million people living in the Maryland suburbs -- more people than are in the entire metropolitan area at present.

- 1. Montgomery County is expected to have 1.5 million.

- 2. Prince George's County above is expected to have over 2 million people by that time.

- B. In the Virginia suburbs also, there will be over 3 million people -- again, more than the current metropolitan total.

- 1. The greatest concentration will be in Fairfax County, which is expected to have approximately

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1.7 million people by the year 2000. (Fairfax County today has less than 450,000 people.)

2. The Virginia suburbs as a whole will be three times as big as they are now -- in just thirty years.

C. By the year 2000 we will have four jurisdictions with over a million residents each -- Montgomery and Prince George's Counties; Fairfax County; and the District of Columbia.

Implications for Water and Sewer Facility Planning, Water Supply and Pollution Control

- A. The overall, general implications for our current water and sewage problems in the Potomac Basin are clear: they will magnify significantly, dramatically, and in a short period of time.
- B. Appropriate action must be planned and executed before the problems get out of hand.
- C. For detailed planning the anticipated future population will have to be distributed or allocated to the numerous drainage basins in the metropolitan area.
- D. The Council of Governments is already at work on this study and task; it consists of two major thrusts:

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We are working with and using an activity allocation model of population growth, and we are naturally discussing the problems with each of our jurisdictions and agencies.

It might be interesting for the conference to review some of the activities and some of the work that we expect this activity allocation model will perform for us.

This activity allocation model appears to be one of the most promising techniques developed in recent years for distributing a control population total throughout a region. The use of such a model enables a planning agency to establish criteria for development throughout the metropolitan area on a small area basis and then to use large computers to allocate future population to these small areas.

The model that the Council of Governments has been using is called the EMPIRIC Activity Allocation Model, and has been under study for the past year. During calendar 1970, the necessary adjustments will have been made and the necessary input information will be available; the model will then be put in operation.

When operational, this model will furnish

the following types of information on a small area basis, "small areas" here being used to include clusters of census tracts, basically. We will consider the data on the basis of employment; population, by age, income, and family size.

The interesting thing to note about this model is that the projections that it will make will not be a "single-shot" projection to the year 2000, but will instead provide a series of projections by time intervals.

The model will produce projections initially for the years 1975, 1985 and 1995; in years to come, the model will be used to make projections for target years as the projections come to be needed.

The model builds upon "current" patterns of development for each forecast period. This means that the base year for the 1975 forecast will be 1968; for the 1985 forecast, the base year will be 1975; and for the 1995 forecast, the base year will be 1985.

In this way the model is better able to actually simulate development and respond to past development so that the projections acquired through the use of the model are more nearly up to date on a continuing basis.

Throughout the process of projecting future population and distributing it throughout the region, the

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Council of Governments has been, and will be, in constant communication with the affected jurisdictions and agencies.

Through the policy committee structure of the Council of Governments, which involves many of the local elected officials in studies of such distinct areas as public safety, transportation planning, land use planning, community resources, and health and environmental protection, the Council of Governments is in close communication with the political jurisdictions of the area.

Through our technical committee, we maintain contact with the planning agencies and the water and sewer authorities in the region -- and, parenthetically, I almost feel, appearing before this conference today, as if it were an unofficial session of our Regional Sanitary Advisory Board. As I look across the team, Mr. McKee, Mr. McKewen, Mr. Johnson, Mr. Jensen, Mr. Hope, Mr. Jackson and Mr. Paessler all serve on our sanitary board, so that this should give you a feel for the contact the Council of Governments has with these problems.

There are other representatives of our board in the audience, I might add.

In retrospect, summarizing what we have said, and later in the program our Executive Director will

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appear and make some more generalized and policy related comments, the Council of Governments believes not only in dealing with the water pollution problem and the population problem, which are really parts of the same problem, that it is only through coordinated, cooperative planning that we will, in any event, be able to solve the problems of tomorrow, hopefully, before they happen.

Thank you very much, Mr. Chairman.

SECRETARY KLEIN: Would you please remain at the lectern?

Do any of the conferees have questions to ask of Dr. Lentz at this time? I have, if I may.

Number 1, do you have these projections set not just for 2000, but for the years 1975, 1980, and by five-year increments?

DR. LENTZ: I have a copy of the report of the consultant here, Mr. Chairman.

SECRETARY KLEIN: Do you have that in there? I mean we can't plan just for 2000; we have to plan in advance as it goes step by step.

DR. LENTZ: Yes, sir, we do have that information.

SECRETARY KLEIN: Fine. Do you also have

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in there the percentage of the budgets that are used for water and for sewerage as we go along? Has the percentage of the budget remained the same, or increased or lessened from these different areas for these purposes?

DR. LENTZ: Mr. Chairman, in answer to that question I have a member of the Council of Governments staff in the audience who has been reviewing water and sewer plans for the past year as part of the requirement for the Department of Housing and Urban Development. I would like to call on Mr. Frank Price to respond to that question.

MR. PRICE: Mr. Chairman, in answer to your first question, if you would like, although this is a preliminary report and is still subject to review, I could leave this copy of the consultant's report of population increase for you as part of the record.

SECRETARY KLEIN: I would appreciate that.

Mr. Price, if I may rephrase the question for you, what I am getting at is this: Has the pollution aspect of the budget been cut into by using the budgets here for other purposes? I would like to know whether the percentage of the budget for this area has remained constant, gone up or gone down percentagewise with the

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total budget since the last conference in 1958?

MR. PRICE: Mr. Chairman, we haven't gone into that kind of detail. We have compiled programs of the local jurisdictions, the current programs, but we have not gone into that kind of detail.

SECRETARY KLEIN: I would appreciate it if, before we get our report out, you could summarize the items that you have.

We would like to know whether pollution control has been suffering at the hands of other items in these budgets of local governments.

DR. LENTZ: Mr. Chairman, if you will keep the record open, we will attempt to answer that question for you.

SECRETARY KLEIN: Thank you. Any further questions from the conferees?

(There was no response.)

SECRETARY KLEIN: Thank you very much.

(The following document was submitted by Dr. Lentz for inclusion in the record:)

PRELIMINARY REPORT

METROPOLITAN WASHINGTON ECONOMIC
AND POPULATION STUDY
PROJECTIONS

Prepared for
Metropolitan Washington Council of Governments

January 1969

HAMMER, GREENE, SILER ASSOCIATES
Washington-Atlanta
1140 Connecticut Avenue, N.W.
Washington, D. C. 20036

* * *

INTRODUCTION

This report sets forth preliminary findings

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and projections resulting from the continuing study of the Metropolitan Washington economy and population. The study area is the Washington SMSA as defined in 1967, which is coincident with the area covered by the Metropolitan Washington Council of Governments.

This preliminary report follows and extends the Labor Force Supply and Demand Report, which was commissioned by COG in March 1968, as a part of this study, and which developed the statistical framework for measuring significant economic and demographic trends up to the year 1968. The projections reflect an extension of pertinent trends and anticipated developments over the period 1970 to 2000.

The purpose of this report is to provide general guidelines and data for more detailed planning studies of the currently defined Washington SMSA. The data and projections are presented on the area basis of counties and independent cities. They represent the potential growth that can be anticipated, but they are not necessarily predictions of future growth. Certain basic assumptions underlie the projections. Also, for some jurisdictions, specific assumptions are set forth that affect the range of the projections.

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Projections could not be prepared for all the cities and municipalities in the metropolitan area, because key data on vital rates and migration were not available for civil divisions below the county level except in the Virginia suburbs where independent cities are considered as a separate local government unit from the counties. Projections for other cities will be obtained through an allocation modeling process, using the area totals as data inputs.

Section I. GROWTH FORCES AFFECTING METROPOLITAN WASHINGTON

The overall dimensions of Metropolitan Washington's economy and population in the future will be shaped to a significant extent by "external" factors: The main economic functions of the metropolitan area are national and international in scope; at least one-half of the future population growth will result from immigration from other areas of the nation.

However, the "mix" of economic activities and the structure and composition of the population in the

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future will be strongly affected by "internal" factors -- or more specifically the existing mix of activities and the existing composition of the population. Essentially, the outlook for the future can be characterized as much more of the same, plus an added layer of new economic activities and functions associated with a mass urban market concentration of typically higher income, highly trained and professionally skilled population. The other side of the coin presages also an increase in the number of relatively disadvantaged, poorly trained, lower income population. Hence, the metropolitan area faces major challenges of growth at the same time that major remedial public programs are called for to maintain the general welfare.

In this study, a range of projections was constructed to represent the magnitude of opportunities and the potential effect public policies and programs -- or the lack of such programs -- can have on the magnitude and relative quality of future growth throughout the metropolitan area. The following describes the major external forces which will affect Metropolitan Washington's future.

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Regional Perspective

Washington is the southern anchor of the metropolitan backbone of Megalopolis, a gateway between the North and the South. It is strategically located to serve as a major commercial city: to the north lies the mass urban-industrial belt; to the south the rural-industrial belt of the Piedmont Plateau extends into the heart of the Southeast. Washington is a natural focal point for commercial interchange between these rapidly growing regions.

Washington will continue to serve in its historical functional roles as the primary national administrative center and a major communications center. However, new functional roles can be anticipated between 1970 and 2000. These new roles will very likely be the typical regional center roles -- providing goods and services to a large region with a growing population and an expanding economic base. This implies a rapid expansion of economic activities which have been essentially service, or nonbasic heretofore. It implies a diversification of the economic profile of the metropolitan area from almost complete dependence on government employment and payrolls, to a less specialized but

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relatively more basic economy; becoming a larger "producer" of goods in addition to services

The reason for this outlook lies in the relative position of Metropolitan Washington within the Eastern Seaboard Region. Recent trends show that Washington's relative position in the Region has been enhanced chiefly because other major metropolitan areas in the Eastern Seaboard have been unable to realize the latent economic opportunities of the Region's population and resources, due largely to the magnitude of their own local, internal problems. Washington's problems have a better chance of being resolved successfully because the local problems do not stem directly from the existing economic structure of the local area. Essentially, Washington's problems can be ameliorated by expanding the local economic structure, while in most major metropolitan areas the solution to local problems requires major changes in the local economic structures.

Metropolitan Washington, within the perspective of the Eastern Seaboard Region, will very likely become more attractive to both population and economic activities in proportion to its relative success or failure to remedy some of the fundamental local problems,

such as housing, job creation, worker training, renewal of blighted areas, and some of the pressing social problems related to race, education, crime, and welfare. The meaning of this outlook, in terms of possible dimensions of future growth becomes clear from analysis of recent national and State population projections.

External Growth Pressures

Table 1 illustrates the dimensions of future population growth potentials as viewed by the U. S. Bureau of the Census. The data indicate that the national population gain over the 35-year period, 1965-2000, very likely will range between 87 million to 140 million persons. It should be noted that these data are based on an assumption of declining birth rates and can be considered as conservative. Further, it is likely that at least 80 to 85 percent of this growth will occur in the 224 major metropolitan areas of the Nation.

Table 1. PROJECTIONS OF U.S. POPULATION, 1965-2000

	<u>In Thousands</u>		<u>Change 1965-2000</u>	
	<u>1965</u>	<u>2000</u>	<u>Number</u>	<u>Percent</u>
Series B	195,685	335,977	140,292	71.7%
Series C	195,685	307,803	112,118	57.3%
Series D	195,685	282,642	86,957	44.4%

Note: Projections by U.S. Bureau of the Census, based on assumed trends in births and deaths. For births, Series B assumes 3,100 births per 1,000 females in the 15 to 45 age groups during the 1965-2000 period; Series C assumes 2,775 births per 1,000, and Series D assumes 2,450 births per 1,000. The death rates for all series are based on the projected life expectancy of 72.3 years (slightly declining mortality) and 76.4 years (rapidly declining mortality) by 2000.

Source: U.S. Bureau of the Census.

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Table 2 shows the counterpart population projections for the Eastern Seaboard States -- the Region defined in this study for analytic purposes only. Basically, the anticipated population gains range between 20 million and 30 million -- roughly 22-23 percent of the national gain, as shown in Table 3.

Table 4 shows that historically the population of the Eastern Seaboard Region has been about 83 percent metropolitan, and that selected metropolitan areas have accounted for an increasing share of the regional population. Washington is the leader in terms of rate of growth since 1960, but second to New York in terms of numbers gained. Washington is the leader in terms of net migration, -- accounting for about two-thirds of all net migration, 1960-1965, to the region's SMSA's. Table 5 shows the population change and migration pattern for the five major SMSA's in the region and the remaining SMSA's in the region as a whole.

Table 2. PROJECTIONS OF POPULATION FOR SELECTED
EASTERN SEABOARD STATES, 1965-2000

	<u>In Thousands</u>		<u>Change 1965-2000</u>	
	<u>1965</u>	<u>2000</u>	<u>Number</u>	<u>Percent</u>
<u>Series I</u>				
B	54,812	84,639	29,827	54.4%
D		74,202	19,390	35.4%
<u>Series II</u>				
B		85,126	30,314	55.3%
D	54,812	74,685	19,873	36.3%

Note: Eastern Seaboard states include Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, District of Columbia, and Virginia.

Projections by U.S. Bureau of the Census. Series I assumes interstate migration will continue within the range observed in 1955-60 and 1960-65; and that national fertility will increase moderately from present levels, (B) or will continue to decline from present levels (D). Series II assumes that interstate migration rates will change so as to result in no net migration (interstate) in 50 years. Series II fertility assumptions are the same as in Series I.

Source: U.S. Bureau of the Census.

Table 3. EASTERN SEABOARD STATES SHARE OF PROJECTED
U.S. POPULATION INCREASE, 1966-2000

	In Thousands		Percent Share
	United States	Eastern Seaboard States	
Series B	140,292	30,314	21.6%
Series D	86,957	19,873	22.9%

Source: U.S. Bureau of the Census.

Table 4. SELECTED METROPOLITAN AREAS AS A SHARE OF
EASTERN SEABOARD POPULATION, 1960 AND 1965

	In Thousands		Change 1960-65	
	1960	1965	Number	Percent
<u>Eastern Seaboard States</u>	50,989	54,812	3,823	7.5%
Selected Metro Areas	24,396	26,273	1,877	7.7%
All Metro Areas	42,342	45,222	2,880	6.8%
<u>Percent of Eastern Seaboard</u>				
Selected Metro Areas	47.8%	47.9%	49.1%	--
All Metro Areas	83.0%	82.5%	75.3%	--

Source: U.S. Bureau of the Census.

Table 5. POPULATION CHANGE AND MIGRATION, SELECTED EASTERN SEABOARD METROPOLITAN AREAS, 1960-1965

	In Thousands			
	1960	1965	Net Change 1960-1965	Net Migration 1960-1965
New York, N.Y.	10,695	11,366	671	+ 123
Philadelphia, Pa.	4,343	4,664	321	+ 60
Boston, Mass.	3,110	3,205	95	- 82
Washington, D.C.	1,989	2,408	419	+ 222
Baltimore, Md.	1,727	1,854	127	+ 4
Other SMSA's ^{1/}	<u>2,532</u>	<u>2,776</u>	<u>244</u>	<u>+ 55</u>
Total	24,396	26,273	1,877	+ 382

^{1/} Richmond, Newport News, Norfolk-Portsmouth, Virginia; Wilmington, Delaware; Trenton, Jersey City, New Jersey.

Source: U.S. Bureau of the Census.

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These data suggest that unless major forces not presently foreseen alter the pattern, the population gains anticipated will fall within the ranges shown in Table 6. These ranges represent the potential population growth attainable for the region and the metropolitan areas, based only on external growth pressures. The ranges represent the probable lower and upper limits of potential growth. The actual growth record of the region and the metropolitan areas will be determined by the interplay of both external and internal factors.

Table 6. PROJECTED POPULATION INCREASE AND POTENTIAL
METROPOLITAN AREA SHARE, 1965-2000

	<u>In Thousands</u> <u>1965-2000</u>
Potential Eastern Seaboard States	20,000-30,000
Potential Share in All Metro Areas	17,000-25,500
Potential Share in Selected Metro Areas	15,000-22,500
Potential Share in Washington Metro Area	4,500- 6,650

Source: U.S. Bureau of the Census, and
Hammer, Greene, Siler Associates.

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Thus, if the national and regional projections can be considered credible, so also can a potential tripling of Metropolitan Washington's population. However, this perspective is only from the outside-in. These data, in effect, represent potential growth limits. The determinants of future growth will be a mixture of both "external" forces, public policies and actions, and "internal" response to growth potentials. The data only indicate that the growth potential exists within the Eastern Seaboard Region.

However, to obtain a balanced evaluation of future growth, it is necessary to carefully evaluate the growth factors within the metropolitan area. The following covers the major internal growth factors.

Internal Growth Pressures

The actual future growth of Metropolitan Washington will be determined partially by the capacity of the existing population to reproduce itself, partially by the viability of the metropolitan economy -- the capacity of the economy to generate new jobs -- and, partially, by the capacity of the metropolitan area to

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accommodate, or absorb, new growth. The past growth record indicates that, up to now, at least, the growth rate implied by national projections has been reached in the metropolitan area.

Population Growth. Table 7 shows the recent population growth pattern and indicates that a metropolitan growth rate capable of doubling the population in 14 to 15 years has been sustained since 1960. Further, the recent growth rate in the suburbs, where most of the future growth can be accommodated, indicates a growth rate capable of doubling in 10 to 12 years. Should this magnitude of growth over the 1960-1968 period be continued over these time spans, it should be noted that a subsequent halving of the growth rate over a following comparable time span would result in about the same numerical increase of population. Thus, even if the growth rate drops substantially the population will still increase dramatically.

Table 7. RECENT POPULATION TRENDS, WASHINGTON METROPOLITAN AREA

	In Thousands		Change	
	1960	Dec. 1967 ^{1/}	Number	Percent
Maryland Suburbs	698.3	1,062.8	364.5	52.2%
District of Columbia	764.0	804.7	40.7	5.3%
Virginia Suburbs	<u>604.1</u>	<u>850.3</u>	<u>246.2</u>	<u>40.8%</u>
Total	2,066.4	2,717.8	651.4	31.5%

^{1/} Projection based on vital statistics available 1960-1966-67 and estimates of migration from household unit method, U.S. Bureau of the Census, and other sources.

Source: Hammer, Greene, Siler Associates.

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Job Growth. The generator of this recent population growth has been an even faster rate of job growth. Table 8 shows recent employment trends in Metropolitan Washington.

Jobs have increased faster than population over the past eight years. Gains in Federal government employment led the job growth, but substantial increases in employment in the suburbs have occurred and the employment profiles of the suburbs has changed sharply in recent years. Much of the change is related to Federal Government activities and the location of Federal offices and installations in the suburbs. However, the growth of private sector economic activities in the suburbs has probably been more significant in setting the stage for future changes in the functional economic roles of the Washington economy than the growth of Federal Government employment.

Table 8. RECENT EMPLOYMENT TRENDS, WASHINGTON METROPOLITAN AREA

	<u>1960</u>	<u>1968</u>	<u>Change</u>	
			<u>Number</u>	<u>Percent</u>
Maryland Suburbs	154,612	275,550	120,938	78.2%
District of Columbia	509,991	617,650	107,659	21.1%
Virginia Suburbs	<u>154,084</u>	<u>255,000</u>	<u>100,916</u>	65.5%
Total	818,687	1,148,200	329,513	40.2

Source: U.S. Department of Employment Security,
District of Columbia, and estimates by
Hammer, Greene, Siler Associates.

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Section II. PROJECTIONS OF THE FUTURE ECONOMY
AND POPULATION

A number of long-range population and employment projections have been made of Metropolitan Washington in the past few years. Generally, local planning has been based on the projections incorporated with the Year 2000 Plan which are published in the Regional Development Guide. However, recent growth has surpassed the trends of growth implicit in the Regional Development Guide. The pattern of recent growth has partly followed the principles laid out in the Year 2000 Plan. This suggests that the time frame of the 2000 Plan may now be out of phase with the physical development of the metropolitan area. It suggests further that the magnitude of growth planned for by 2000 may need to be accommodated by 1985-1990. Table 9 shows a comparison of the Regional Development Guide projections with projections developed for this study.

General Approach to Projections

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The projections which follow represent two different approaches to the problem of "how many" and "how big" in Metropolitan Washington. The population projections are based on birth and death rates and immigration patterns observed in the past and the national population projection series. Adjusted migration rates by age group were constructed on the basis of the past 1950-1960 and 1950-1966 patterns of population growth. The housing unit count method and the Census school enrollment method were utilized also as a check on the migration rates.

The employment projections are based on an analysis of the existing and potential functional roles of the economy, latent economic opportunities which might be realized through positive development policies, and analysis of past trends by economic sector. The income projections are based largely on the historical data series published by the U. S. Department of Commerce.

Table 9. COMPARISONS OF POPULATION PROJECTIONS FOR
WASHINGTON METROPOLITAN AREA, BY MAJOR
SUBREGIONS, 1970, 1980, 1990 AND 2000

	<u>1970</u>	<u>1980</u>	<u>1990</u>	<u>2000</u>
<u>Maryland Suburbs</u>				
Reg. Dev. Guide	1,133,000	1,511,800	1,855,350	2,191,400
HGSA				
High	1,236,269	2,084,712	3,250,680	4,296,731
Low	1,236,269	1,844,483	2,538,640	3,106,341
<u>District of Columbia</u>				
Reg. Dev. Guide	833,800	887,350	931,200	966,960
HGSA				
High	814,662	860,057	948,126	1,070,748
Low	814,662	843,839	916,391	1,012,709
<u>Virginia Suburbs</u>				
Reg. Dev. Guide	959,250	1,342,306	1,731,900	2,129,300
HGSA				
High	964,374	1,527,311	2,499,748	3,568,147
Low	964,374	1,397,207	2,001,073	2,642,953
<u>Metropolitan Area</u>				
Reg. Dev. Guide	2,926,050	3,741,456	4,518,450	5,287,600
HGSA				
High	3,015,305	4,472,080	6,698,554	8,935,636
Low	3,015,305	4,085,529	5,456,104	6,762,003

Source: Regional Development Guide, Appendix 2
Regional Statistics and Hammer, Greene,
Siler Associates.

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Tables 10 and 11 show the projections of jobs and personal income in the metropolitan area. High and low levels of population, employment, and income were constructed. The range was based on assumptions concerning public policies and actions in the metropolitan area. The following sets forth the major assumptions and conditions governing the range of the projections.

General Assumptions: National

1. It is assumed that Washington, D. C., will continue to be the Nation's capital and seat for the Federal Government activities.
2. The rate of growth of the national economy will average about 3 to 3-1/2 percent over the next 32 years.
3. The United States will not be involved in any major global wars, will suffer no major epidemics, natural disasters or economic depressions that would significantly retard or affect national growth.
4. The United States Government will continue to participate and encourage private and public efforts in the fields of space, physical and social sciences research and development activities during the forecast period.

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5. There will be no major shift in the location and distribution of Federal installations and jobs which might adversely affect the growth of the Washington area economy.

Specific Assumptions: Regional

1. Growth of the national population will follow the general patterns according to the U. S. Bureau of the Census National Population Projection Series C.

2. According to the National Population Projection Series C, the population of the United States will increase by about 111 million persons between now and the year 2000.

3. About 80 to 85 percent of the net growth of the population between now and the year 2000 will take place in the Nation's metropolitan areas.

4. Population in the Eastern Seaboard will increase by about 30 million persons during the next 32 years.

5. Nearly 85 percent of the population growth in the Eastern Seaboard States will take place

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in the metropolitan areas.

6. About 85 percent of the population growth in the Eastern Seaboard Metropolitan Areas will be in five major metropolitan areas -- Boston, Massachusetts; New York, New York; Philadelphia, Pennsylvania; Baltimore, Maryland; and Washington, D. C.

General Assumptions: Metropolitan Area

1. The systematic area-wide coordinated planning will continue and the existing area-wide plans will be carried out essentially as they exist.

2. The local policies will not generally be in contradiction to the goals set by the overall regional plans.

3. The goals and policies of the Federal Government as they relate to the Washington area activities will be in harmony with local goals and policies and that continuous coordination will exist between the local and regional planning agencies and the Federal Government.

4. The annual net gain in Federal jobs in the metropolitan area will average about 10,000 over

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the forecast period.

5. There will be gradual decentralization of Federal jobs within the metropolitan area so that over the forecast period, a larger share of new Federal jobs will be situated in the suburban counties.

6. Water, sewer, and transportation facilities will not act as constraints to development in the metropolitan area.

Subarea Projections

The following tables show the projections of population by selected civil divisions. Employment is shown by the same civil divisions and by industry group. It should be noted that these are subject to final adjustments which may result from further land use studies now in process. They are thus preliminary in nature for the selected subareas. However, the overall metropolitan area data will not change appreciably, if at all.

Table 10. COMPARISONS OF AT PLACE EMPLOYMENT PROJECTIONS FOR
WASHINGTON METROPOLITAN AREA BY MAJOR SUBREGIONS;
1970, 1980, 1990 and 2000

	<u>4/1/68</u>	<u>1970</u>	<u>1980</u>	<u>1990</u>	<u>2000</u>
<u>Maryland Suburbs</u>					
Actual	275,550				
Reg. Dev. Guide		283,800	400,700	536,900	663,500
HGSA					
I		304,500	420,400	571,500	759,300
II		311,200	443,250	634,900	889,600
<u>District of Columbia</u>					
Actual	617,650				
Reg. Dev. Guide		576,600	669,700	733,800	765,300
HGSA					
I		657,500	796,100	913,800	1,011,100
II		665,800	838,420	1,014,900	1,190,600
<u>Virginia Suburbs</u>					
Actual	255,000				
Reg. Dev. Guide		288,900	436,950	580,550	698,700
HGSA					
I		293,200	432,200	599,800	800,000
II		306,280	455,860	662,190	940,950
<u>Metropolitan Area</u>					
Actual	1,148,200				
Reg. Dev. Guide		1,149,300	1,507,350	1,851,250	2,127,500
HGSA					
I		1,255,200	1,648,700	2,085,100	2,570,400
II		1,283,280	1,737,530	2,311,990	3,021,150

Source: Regional Development Guide, Appendix 2 Regional Statistics and Hammer, Greene, Siler Associates.

Table 11. PROJECTIONS OF TOTAL PERSONAL INCOME-WASHINGTON
METROPOLITAN AREA, 1965-2000
(In Billions of Dollars)

	<u>High Population</u>		<u>Low Population</u>	
	<u>High</u>	<u>Low</u>	<u>High</u>	<u>Low</u>
	<u>Income</u>	<u>Income</u>	<u>Income</u>	<u>Income</u>
1970	\$ 13.5	\$13.3	\$13.4	\$13.4
1975	19.3	19.0	19.0	18.7
1980	27.6	26.8	26.4	25.2
1985	38.8	36.9	35.4	32.6
1990	54.4	49.6	45.7	40.9
1995	76.3	65.1	56.3	49.2
2000	\$107.0	83.5	\$65.7	\$56.5

Note: In constant 1968 dollars.

Source: Hammer, Greene, Siler
Associates.

Section III. PROJECTIONS BY JURISDICTIONS

Table 12. HIGH PROJECTION OF POPULATION FOR WASHINGTON
METROPOLITAN AREA BY JURISDICTIONS, 1970-2000

	1970	1975	1980	1985	1990	1995	2000
Montgomery County	505,618	630,455	800,967	1,004,970	1,239,370	1,469,277	1,659,924
Prince George's Co.	730,651	959,894	1,283,745	1,632,334	2,011,310	2,361,614	2,636,807
Maryland Suburbs	1,236,269	1,590,349	2,084,712	2,637,304	3,250,680	3,830,891	4,296,721
District of Columbia	814,662	836,586	860,057	895,855	948,126	1,007,444	1,070,748
Alexandria City	121,664	135,962	152,136	172,991	200,087	232,221	266,425
Arlington County	189,684	206,416	235,064	278,169	345,028	418,414	495,808
Fairfax City	26,455	34,866	46,360	61,649	79,374	98,009	116,990
Fairfax County	449,507	592,214	817,307	1,103,934	1,431,701	1,750,260	1,988,277
Falls Church	15,505	19,938	26,273	34,370	43,996	55,113	67,933
Loudoun County	41,845	51,406	62,846	76,309	96,076	127,914	172,032
Prince William Co.	119,714	149,486	187,325	238,737	303,486	378,097	460,682
Virginia Suburbs	964,374	1,190,288	1,527,311	1,966,159	2,499,748	3,060,028	3,568,147
Total Metropolitan Area	3,015,305	3,617,223	4,472,080	5,499,318	6,698,554	7,898,363	8,935,626

Source: Hammer, Greene, Siler Associates.

Table 13. LOW PROJECTION OF POPULATION, WASHINGTON
METROPOLITAN AREA BY JURISDICTIONS, 1970-2000

	1970	1975	1980	1985	1990	1995	2000
Montgomery County	505,618	627,919	759,837	908,184	1,066,036	1,213,622	1,345,346
Prince George's Co.	730,651	887,084	1,084,646	1,278,716	1,472,604	1,638,026	1,760,995
Maryland Suburbs	1,236,269	1,515,003	1,844,483	2,186,900	2,538,640	2,851,648	3,106,341
District of Columbia	814,662	828,085	843,839	873,169	916,391	965,596	1,012,709
Alexandria City	121,664	132,171	144,039	158,319	173,467	188,538	202,521
Arlington County	189,684	202,415	218,095	238,735	267,288	305,279	354,851
Fairfax City	26,455	33,604	42,627	53,590	66,468	78,487	89,279
Fairfax County	449,507	567,843	729,826	912,776	1,101,382	1,294,774	1,433,178
Falls Church	15,505	19,154	23,628	28,717	34,155	39,850	45,816
Loudoun County	41,845	51,406	62,846	76,309	91,630	109,281	130,006
Prince William Co.	119,714	145,028	176,146	216,856	266,683	322,608	387,302
Virginia Suburbs	964,374	1,151,621	1,397,207	1,685,302	2,001,073	2,338,817	2,642,953
Total Metropolitan Area	3,015,305	3,494,709	4,085,529	4,745,371	5,456,104	6,156,061	6,762,003

Source: Hammer, Greene, Siler Associates.

EMPLOYMENT PROJECTION I

Table 14. AT-PLACE EMPLOYMENT PROJECTIONS FOR THE WASHINGTON, D.C.
METROPOLITAN AREA BY FIVE YEAR INTERVALS, 1970-2000
(Projection I)

	1970	1975	1980	1985	1990	1995	2000
Agricultural, Forestry and Fishery	6,300	5,650	4,820	3,900	2,900	2,000	1,000
Construction	66,100	76,200	86,200	96,200	106,500	117,000	128,500
Manufacturing	49,100	58,400	68,200	78,400	89,200	100,000	110,100
TCU 1/	60,800	68,500	76,200	84,300	93,200	102,600	112,800
Trade	214,100	244,100	280,100	318,000	365,200	413,900	465,100
Wholesale	35,600	37,200	38,500	40,200	42,000	43,700	45,700
Retail	178,500	206,900	241,600	277,800	323,200	370,200	419,400
FIRE 2/	64,400	71,200	79,000	87,700	97,500	107,800	119,000
Services	237,200	275,600	318,800	363,500	412,300	464,700	520,900
Government	445,600	518,600	594,100	669,100	744,100	819,300	899,700
Federal	343,600	395,800	448,700	499,000	548,300	597,300	649,800
State and Local	102,000	122,800	145,400	170,100	195,800	222,000	249,900
Other 3/	111,600	125,850	141,280	157,600	175,200	193,700	213,300
TOTAL	1,255,200	1,444,100	1,648,700	1,858,700	2,085,100	2,321,000	2,570,400

1/ Transportation, Communication and
Public Utilities.

2/ Finance, Insurance and Real Estate.

3/ Includes Self-employed, Domestic
and Household Workers.

Source: Hammer, Greene, Siler Associates.

Table 15. AT-PLACE EMPLOYMENT PROJECTIONS FOR DISTRICT
OF COLUMBIA BY FIVE YEAR INTERVALS, 1970-2000
(Projection 1)

	1970	1975	1980	1985	1990	1995	2000
Agricultural, Forestry and Fishery	100	50	20	-	-	-	-
Construction	21,800	24,700	27,200	29,200	31,000	32,500	34,000
Manufacturing	22,500	23,000	23,500	23,900	24,300	24,600	24,800
TCU 1/	30,800	31,500	31,800	32,000	32,200	32,400	32,600
Trade	85,800	88,700	92,500	96,500	100,700	105,100	109,800
Wholesale	20,800	21,000	20,700	20,400	20,000	19,500	19,000
Retail	65,000	67,700	71,800	76,100	80,700	85,600	90,800
FIRE 2/	34,300	37,500	41,000	44,700	48,500	52,400	56,300
Services	138,200	158,900	180,300	201,000	221,000	239,800	256,600
Government	264,200	298,200	327,400	352,500	373,000	390,000	405,000
Federal	220,500	245,500	265,500	280,500	292,000	301,000	309,000
State and Local	43,700	52,700	61,900	72,000	81,000	89,000	96,000
Other 3/	59,800	66,350	72,380	78,000	83,100	87,700	92,000
TOTAL	657,500	728,900	796,100	857,800	913,800	964,500	1,011,100

1/ Transportation, Communication and
Public Utilities.

2/ Finance, Insurance and Real Estate.

3/ Includes Self-employed, Domestic
and Household Workers.

Source: Hammer, Greene, Siler Associates.

Table 16. AT-PLACE EMPLOYMENT PROJECTIONS FOR MONTGOMERY COUNTY,
MARYLAND, BY FIVE YEAR INTERVALS - 1970-2000

	(Projection 1)			
	<u>1970</u>	<u>1975</u>	<u>1980</u>	<u>1985</u>
Agricultural, Forestry and Fishery	2,500	2,300	2,000	1,650
Construction	15,300	17,100	19,000	21,000
Manufacturing	7,300	8,600	10,300	12,300
TCU 1/	4,400	5,200	6,100	7,200
Trade	35,100	42,100	50,800	59,900
Wholesale	3,200	3,400	3,700	4,100
Retail	31,900	38,700	47,100	55,800
FIRE 2/	9,750	10,500	11,500	12,600
Services	39,200	45,000	51,800	59,200
Government	52,100	62,000	73,900	86,500
Federal	36,800	45,200	55,000	65,000
State and Local	15,300	16,800	18,900	21,500
Other 3/	9,700	11,100	12,300	13,700
TOTAL	175,350	203,900	237,700	274,050

	<u>1990</u>	<u>1995</u>	<u>2000</u>
Agricultural, Forestry and Fishery	1,300	900	450
Construction	23,000	25,000	27,000
Manufacturing	14,400	16,900	19,800
TCU 1/	8,600	10,100	12,000
Trade	71,700	83,500	95,300
Wholesale	4,500	5,000	5,700
Retail	67,200	78,500	89,600
FIRE 2/	13,900	15,500	17,300
Services	68,200	78,500	88,400
Go	99,900	113,800	128,500
Federal	75,000	85,000	95,000
State and Local	24,900	28,800	33,500
Other 3/	15,700	17,800	20,100
TOTAL	316,700	362,000	408,850

1/ Transportation, Communication and Public Utilities.

2/ Finance, Insurance and Real Estate.

3/ Includes self-employed, Domestic and Household Workers.

Source: Hammer, Greene, Siler Associates.

Table 17. AT-PLACE EMPLOYMENT PROJECTIONS FOR PRINCE GEORGES
COUNTY, MARYLAND, BY FIVE YEAR INTERVALS, 1970-2000
(Projection I)

	1970	1975	1980	1985	1990	1995	2000
Agricultural, Forestry and Fishery	700	600	500	350	200	100	50
Construction	9,700	11,600	13,500	15,500	17,500	19,500	21,500
Manufacturing	7,500	8,800	10,400	12,200	14,500	17,000	19,500
TCU 1/	5,600	6,300	7,300	8,300	9,600	11,300	13,200
Trade	35,800	42,600	51,200	60,300	72,300	83,800	95,500
Wholesale	3,200	3,600	4,000	4,400	5,000	5,700	6,500
Retail	32,600	39,000	47,200	55,900	67,300	78,100	89,000
FIRE 2/	7,050	7,700	8,500	9,400	10,600	11,900	13,400
Services	13,800	16,700	20,700	25,300	32,100	40,400	51,900
Government	40,700	49,200	60,000	71,500	84,600	99,700	118,200
Federal	23,500	30,100	38,200	46,500	55,300	65,300	77,800
State and Local	17,200	19,100	21,800	25,000	29,300	34,400	40,400
Other 3/	8,300	9,400	10,600	11,900	13,400	15,200	17,200
TOTAL	129,150	152,900	182,700	214,750	254,800	298,900	350,450

1/ Transportation, Communication and
Public Utilities.

2/ Finance, Insurance and Real Estate.

3/ Includes Self-employed, Domestic
and Household Workers.

Source: Hammer, Greene, Siler Associates.

Table 18. AT PLACE EMPLOYMENT PROJECTIONS FOR ALEXANDRIA CITY,
VIRGINIA BY FIVE YEAR INTERVALS, 1970-2000
(Projection I and II)

	1970	1975	1980	1985	1990	1995	2000
Agricultural, Forestry and Fishery	50	25	--	--	--	--	--
Construction	3,100	3,600	4,000	4,270	4,300	4,200	4,000
Manufacturing	2,550	2,600	2,560	2,420	2,200	2,000	1,800
TCU 1/	4,200	5,000	5,800	6,500	7,100	7,600	8,000
Trade	10,450	11,910	12,800	13,250	13,600	13,600	13,500
Wholesale	1,650	1,580	1,500	1,350	1,200	1,050	900
Retail	8,800	10,330	11,300	11,900	12,400	12,550	12,600
FIRE 2/	2,900	3,200	3,600	4,100	4,600	5,100	5,600
Services	10,100	11,200	12,400	13,800	15,400	16,800	18,000
Government	8,700	10,100	12,100	13,700	14,900	16,100	17,600
Federal	6,000	7,000	8,500	9,500	10,000	10,500	11,000
State and Local	2,700	3,100	3,600	4,200	4,900	5,600	6,600
Other 3/	4,150	4,680	5,300	5,900	6,600	7,300	7,800
TOTAL	46,200	52,315	58,560	63,940	68,700	72,700	76,300

1/ Transportation, Communication and Public
Utilities.

2/ Finance, Insurance and Real Estate.

3/ Includes Self-employed, Domestic and
Household Workers.

Source: Hammer, Greene, Siler Associates.

Table 19. AT-PLACE EMPLOYMENT PROJECTIONS FOR ARLINGTON
COUNTY, VIRGINIA BY FIVE YEAR INTERVALS, 1970-2000
(Projection I and II)

	1970	1975	1980	1985	1990	1995	2000
Agricultural, Forestry and Fishery	70	50	10	5	--	--	--
Construction	4,380	5,250	6,100	7,170	8,000	8,600	8,900
Manufacturing	1,500	1,600	1,500	1,400	1,300	1,200	1,100
TCU 1/	10,900	12,400	13,700	14,800	15,700	16,400	17,000
Trade	18,500	22,150	25,650	29,100	32,100	34,480	35,700
Wholesale	3,800	4,000	3,900	3,800	3,500	3,100	2,700
Retail	14,700	18,150	21,750	25,300	28,600	31,380	33,000
FIRE 2/	4,600	5,100	5,700	6,500	7,300	8,100	8,900
Services	11,600	13,000	14,600	16,400	18,000	19,500	20,900
Government	42,900	48,500	54,800	60,800	65,900	70,100	73,200
Federal	37,300	42,100	47,500	52,500	56,500	59,500	61,000
State and Local	5,600	6,400	7,300	8,300	9,400	10,600	12,200
Other 3/	5,650	6,460	7,400	8,600	9,750	10,800	11,500
TOTAL	100,100	114,510	129,460	144,775	158,050	169,180	177,200

1/ Transportation, Communication and Public
Utilities.

2/ Finance, Insurance and Real Estate.

3/ Includes Self-employed, Domestic and
Household Workers.

Source: Hammer, Greene, Siler Associates.

Table 20. AT-PLACE EMPLOYMENT PROJECTIONS FOR FAIRFAX CITY,
VIRGINIA BY FIVE YEAR INTERVALS, 1970-2000
(Projection I and II)

	1970	1975	1980	1985	1990	1995	2000
Agricultural, Forestry and Fishery	--	--	--	--	--	--	--
Construction	800	900	1,000	1,100	1,190	1,280	1,400
Manufacturing	40	60	80	100	110	100	90
TCU 1/	350	600	800	900	1,000	1,100	1,200
Trade	1,830	2,140	2,490	2,680	2,750	2,820	2,840
Wholesale	230	240	260	280	300	320	340
Retail	1,600	1,900	2,230	2,400	2,450	2,500	2,500
FIRE 2/	380	430	490	560	640	720	800
Services	1,300	1,700	2,200	2,800	3,500	4,300	5,000
Government	500	700	1,000	1,400	1,700	2,100	2,600
Federal	--	--	--	--	--	--	--
State and Local	500	700	1,000	1,400	1,700	2,100	2,600
Other 3/	1,400	1,560	1,750	1,950	2,150	2,300	2,400
TOTAL	6,600	8,090	9,810	11,490	13,040	14,720	16,330

1/ Transportation, Communication and Public
Utilities.

2/ Finance, Insurance and Real Estate.

3/ Includes Self-employed, Domestic and
Household Workers.

Source: Hammer, Greene, Siler Associates.

Table 21. AT-PLACE EMPLOYMENT PROJECTIONS FOR FALLS CHURCH CITY,
VIRGINIA BY FIVE YEAR INTERVALS, 1970-2000
(Projection I and II)

	1970	1975	1980	1985	1990	1995	2000
Agricultural, Forestry and Fishery	5	--	--	--	--	--	--
Construction	1,000	1,100	1,200	1,340	1,450	1,520	1,600
Manufacturing	110	140	160	180	190	200	210
TCU 1/	700	900	1,000	1,100	1,200	1,300	1,400
Trade	2,220	2,590	3,020	3,370	3,550	3,680	3,760
Wholesale	120	130	150	170	200	230	260
Retail	2,100	2,460	2,870	3,200	3,350	3,450	3,500
FIRE 2/	650	700	750	800	850	900	950
Services	3,300	3,800	4,400	5,000	5,500	6,000	6,500
Government	1,000	1,100	1,200	1,500	1,700	1,900	2,200
Federal	--	--	--	--	--	--	--
State and Local	1,000	1,100	1,200	1,500	1,700	1,900	2,200
Other 3/	700	800	900	1,000	1,100	1,200	1,300
TOTAL	9,685	11,130	12,630	14,290	15,540	16,700	17,920

1/ Transportation, Communication and
Public Utilities.

2/ Finance, Insurance and Real Estate.

3/ Includes Self-employed, Domestic
and Household Workers.

Source: Hammer, Greene, Siler Associates.

Table 22. AT-PLACE EMPLOYMENT PROJECTIONS FOR FAIRFAX COUNTY,
VIRGINIA BY FIVE YEAR INTERVALS, 1970-2000
(Projection 1)

	1970	1975	1980	1985	1990	1995	2000
Agricultural, Forestry and Fishery	550	460	350	240	120	70	20
Construction	7,800	9,150	10,300	11,260	12,260	13,000	13,400
Manufacturing	5,000	8,100	11,100	14,600	18,600	22,400	25,600
TCU 1/	2,000	3,900	5,600	7,700	10,000	12,300	14,200
Trade	18,930	23,940	30,000	36,600	45,000	53,400	62,900
Wholesale	2,300	2,600	3,000	3,600	4,400	5,100	5,900
Retail	16,630	21,340	27,000	33,000	40,600	48,300	57,000
FIRE 2/	3,850	4,670	5,510	6,640	7,910	9,230	10,850
Services	14,900	18,400	22,500	26,600	31,000	36,500	43,500
Government	25,000	34,300	44,200	54,600	66,200	77,100	88,400
Federal	13,000	16,900	21,700	27,500	34,500	41,000	48,000
State and Local	12,000	17,400	22,500	27,100	31,700	36,100	40,400
Other 3/	15,650	18,000	21,500	25,300	29,800	34,800	41,000
TOTAL	93,680	120,920	151,060	183,540	220,890	258,800	299,870

1/ Transportation, Communication and
Public Utilities.

2/ Finance, Insurance and Real Estate.

3/ Includes Self-employed, Domestic and
Household Workers.

Source: Hammer, Greene, Siler Associates.

Table 23. AT-PLACE EMPLOYMENT PROJECTIONS FOR PRINCE WILLIAM COUNTY, VIRGINIA BY FIVE YEAR INTERVALS, 1970-2000
(Projection I)

	1970	1975	1980	1985	1990	1995	2000
Agricultural, Forestry and Fishery	555	465	350	260	140	90	30
Construction	1,600	2,000	2,600	3,350	4,900	7,200	10,000
Manufacturing	1,800	3,800	5,900	7,600	9,000	10,300	11,200
TCU 1/	1,150	1,800	2,800	4,000	5,400	6,900	8,800
Trade	3,770	5,380	7,900	10,900	15,200	20,660	26,900
Wholesale	200	400	800	1,300	1,700	2,100	2,400
Retail	3,570	4,980	7,100	9,600	13,500	18,560	24,500
FIRE 2/	600	900	1,200	1,500	2,000	2,450	3,000
Services	2,800	4,300	6,300	8,600	11,300	14,800	20,000
Government	7,400	10,000	13,100	17,700	24,200	32,800	42,500
Federal	4,500	6,000	7,800	11,000	16,000	23,000	31,000
State and Local	2,900	4,000	5,300	6,700	8,200	9,800	11,500
Other 3/	2,750	3,400	4,350	5,550	6,900	8,700	10,700
TOTAL	22,425	32,045	44,500	59,460	79,040	103,900	133,130

1/ Transportation, Communication and Public Utilities.

2/ Finance, Insurance and Real Estate.

3/ Includes Self-employed, Domestic and Household Workers.

Source: Hammer, Greene, Siler Associates.

Table 24. AT-PLACE EMPLOYMENT PROJECTIONS FOR LOUDOUN COUNTY,
VIRGINIA BY FIVE YEAR INTERVALS, 1970-2000
(Projection I)

	1970	1975	1980	1985	1990	1995	2000
Agricultural, Forestry and Fishery	1,770	1,700	1,590	1,395	1,140	840	450
Construction	620	800	1,300	2,010	2,900	4,200	6,700
Manufacturing	800	1,700	2,700	3,700	4,600	5,300	6,000
TCU 1/	700	900	1,300	1,800	2,400	3,200	4,400
Trade	1,700	2,590	3,740	5,400	8,300	12,860	18,900
Wholesale	100	250	490	800	1,200	1,500	2,000
Retail	1,600	2,340	3,250	4,600	7,100	11,260	16,900
FIRE 2/	320	500	750	900	1,200	1,500	1,900
Services	2,000	2,600	3,600	4,800	6,300	8,100	10,100
Government	3,100	4,500	6,400	8,900	12,000	15,700	21,500
Federal	2,000	3,000	4,500	6,500	9,000	12,000	17,000
State and Local	1,100	1,500	1,900	2,400	3,000	3,700	4,500
Other 3/	3,500	4,100	4,800	5,700	6,700	7,900	9,300
TOTAL	14,510	19,390	26,180	34,605	45,540	59,600	79,250

1/ Transportation, Communication and Public Utilities.

2/ Finance, Insurance and Real Estate.

3/ Includes Self-employed, Domestic and Household Workers.

Source: Hammer, Greene, Siler Associates.

EMPLOYMENT PROJECTION II

Table 25. AT-PLACE EMPLOYMENT PROJECTIONS FOR THE WASHINGTON, D.C.
METROPOLITAN AREA BY FIVE YEAR INTERVALS, 1970-2000
(Projection II)

	1970	1975	1980	1985	1990	1995	2000
Agricultural, Forestry and Fishery	6,300	5,650	4,820	3,900	2,900	2,000	1,000
Construction	66,100	76,200	86,200	96,200	106,500	117,000	128,500
Manufacturing	51,200	62,000	74,900	89,900	106,800	125,100	144,600
TCU 1/	62,250	71,150	81,250	92,600	106,100	121,000	139,600
Trade	221,000	256,190	301,860	354,300	421,900	498,280	582,800
Wholesale	36,450	38,800	41,410	44,800	48,600	52,900	57,900
Retail	184,550	217,390	260,450	309,500	373,300	445,380	524,900
FIRE 2/	66,130	74,630	84,800	97,560	111,890	128,320	147,250
Services	244,400	289,650	344,350	407,200	479,800	561,300	655,300
Government	449,700	525,400	606,300	689,800	775,400	864,100	962,700
Federal	343,600	395,800	448,700	499,000	548,300	597,300	649,800
State and Local	106,100	129,600	157,600	190,800	227,100	266,800	312,900
Other 3/	116,200	132,700	153,050	176,050	200,700	229,100	259,400
TOTAL	1,283,280	1,493,570	1,737,530	2,007,510	2,311,990	2,646,200	3,021,150

1/ Transportation, Communication and
Public Utilities.

2/ Finance, Insurance and Real Estate.

3/ Includes Self-employed, Domestic
and Household Workers.

Source: Hammer, Greene, Siler Associates.

Table 26. AT-PLACE EMPLOYMENT PROJECTIONS FOR DISTRICT
OF COLUMBIA BY FIVE YEAR INTERVALS, 1970-2000
(Projection II)

	1970	1975	1980	1985	1990	1995	2000
Agricultural, Forestry and Fishery	100	50	20	00	00	00	00
Construction	21,800	24,700	27,200	29,200	31,000	32,500	34,000
Manufacturing	23,000	24,200	25,500	27,000	28,500	30,000	31,500
TCU 1/	31,300	32,900	34,400	35,900	37,600	39,300	41,300
Trade	87,400	93,100	100,300	108,900	118,000	127,800	139,200
Wholesale	21,200	22,000	22,500	23,000	23,400	23,700	23,900
Retail	66,200	71,100	77,800	85,900	94,600	104,100	115,300
FIRE 2/	35,000	39,400	44,400	50,500	56,700	63,900	71,500
Services	141,200	167,000	195,600	227,000	259,000	292,200	325,700
Government	265,100	300,900	332,500	361,800	386,900	409,300	430,900
Federal	220,500	245,500	265,500	280,500	292,000	301,000	309,000
State and Local	44,600	55,400	67,000	81,300	94,900	108,300	121,900
Other 3/	60,900	69,700	78,500	88,000	97,200	106,800	116,500
TOTAL	665,800	751,950	838,420	928,300	1,014,900	1,101,800	1,190,600

1/ Transportation, Communication and Public
Utilities.

2/ Finance, Insurance and Real Estate.

3/ Includes Self-employed, Domestic and
Household Workers.

Source: Hammer, Greene, Siler Associates.

Table 27. AT-PLACE EMPLOYMENT PROJECTIONS FOR MONTGOMERY
COUNTY, MARYLAND BY FIVE YEAR INTERVALS, 1970-2000
(Projection II)

	1970	1975	1980	1985	1990	1995	2000
Agricultural, Forestry and							
Fishery	2,500	2,300	2,000	1,650	1,300	900	450
Construction	15,300	17,100	19,000	21,000	23,000	25,000	27,000
Manufacturing	7,500	9,100	11,100	13,600	16,600	20,100	24,000
TCU 1/	4,500	5,500	6,550	7,900	9,800	11,800	14,400
Trade	36,000	44,500	54,600	66,100	82,400	99,000	115,900
Wholesale	3,300	3,550	3,900	4,500	5,100	5,800	6,700
Retail	32,700	40,950	50,700	61,600	77,300	93,200	109,200
FIRE 2/	10,000	11,100	12,300	13,900	15,900	18,300	20,900
Services	40,200	47,600	55,700	65,400	78,500	93,300	108,000
Government	52,500	62,900	75,300	88,700	103,500	119,200	135,600
Federal	36,800	45,200	55,000	65,000	75,000	85,000	95,000
State and Local	15,700	17,700	20,300	23,700	28,500	34,200	40,500
Other 3/	9,900	11,700	13,200	15,100	18,100	21,100	24,200
TOTAL	178,400	211,800	249,750	293,350	349,100	408,700	470,450

1/ Transportation, Communication and Public
Utilities.

2/ Finance, Insurance and Real Estate.

3/ Includes Self-employed, Domestic and
Household Workers.

Source: Hammer, Greene, Siler Associates.

Table 28. AT-PLACE EMPLOYMENT PROJECTIONS FOR PRINCE GEORGE'S COUNTY, MARYLAND BY FIVE YEAR INTERVALS, 1970-2000
(Projection II)

	1970	1975	1980	1985	1990	1995	2000
Agricultural, Forestry and Fishery	700	600	500	350	200	100	50
Construction	9,700	11,600	13,500	15,500	17,500	19,500	21,500
Manufacturing	7,800	9,300	11,300	13,800	17,000	20,700	24,900
TCU 1/	5,800	6,600	7,900	9,400	11,200	13,600	16,700
Trade	37,100	44,900	55,500	68,200	84,700	101,800	121,700
Wholesale	3,300	3,700	4,300	5,000	5,800	6,800	8,200
Retail	33,800	41,200	51,200	63,200	78,900	95,000	113,500
FIRE 2/	7,300	8,100	9,100	10,600	12,400	14,500	16,900
Services	14,400	17,600	22,500	28,600	37,600	49,000	66,200
Government	41,400	50,300	61,800	74,600	89,600	107,100	129,300
Federal	23,500	30,100	38,200	46,500	55,300	65,300	77,800
State and Local	17,900	20,200	23,600	28,100	34,300	41,800	51,500
Other 3/	8,600	9,800	11,400	13,400	15,600	18,400	21,900
TOTAL	132,800	158,800	193,500	234,450	285,800	344,700	419,150

1/ Transportation, Communication and Public Utilities.

2/ Finance, Insurance and Real Estate.

3/ Includes Self-employed, Domestic and Household Workers.

Source: Hammer, Greene, Siler Associates.

Table 29. AT-PLACE EMPLOYMENT PROJECTIONS FOR FAIRFAX COUNTY,
VIRGINIA BY FIVE YEAR INTERVALS, 1970-2000
(Projection II)

	1970	1975	1980	1985	1990	1995	2000
Agricultural, Forestry and Fishery	550	460	350	240	120	70	20
Construction	7,800	9,150	10,300	11,260	12,260	13,000	13,400
Manufacturing	5,500	8,800	12,500	16,500	20,700	25,000	29,500
TCU 1/	2,200	4,200	6,300	8,600	11,000	13,500	16,200
Trade	20,800	25,900	33,800	41,300	49,900	59,800	72,300
Wholesale	2,500	2,800	3,400	4,000	4,800	5,800	6,800
Retail	18,300	23,100	30,400	37,300	45,100	54,000	65,500
FIRE 2/	4,200	5,000	6,100	7,400	8,700	10,300	12,400
Services	16,400	20,000	25,200	30,500	36,200	42,500	49,900
Government	26,200	35,700	46,900	58,000	69,700	81,200	94,300
Federal	13,000	16,900	21,700	27,500	34,500	41,000	48,000
State and Local	13,200	18,800	25,200	30,500	35,200	40,200	46,300
Other 3/	17,200	19,500	24,100	28,500	33,100	38,700	44,300
TOTAL	100,850	128,710	165,550	202,300	241,680	284,070	332,320

1/ Transportation, Communication and
Public Utilities.

2/ Finance, Insurance and Real Estate.

3/ Includes Self-employed, Domestic
and Household Workers.

Source: Hammer, Greene, Siler Associates.

Table 30. AT-PLACES EMPLOYMENT PROJECTIONS FOR PRINCE WILLIAM
COUNTY, VIRGINIA BY FIVE YEAR INTERVALS, 1970-2000
(Projection II)

	1970	1975	1980	1985	1990	1995	2000
Agricultural, Forestry and Fishery	555	465	350	260	140	90	30
Construction	1,600	2,000	2,600	3,350	4,900	7,200	10,000
Manufacturing	2,200	4,200	6,700	9,700	13,000	16,500	20,000
TCU 1/	1,400	2,000	3,100	5,000	7,800	10,800	15,000
Trade	4,600	6,000	8,900	13,800	21,900	32,800	45,100
Wholesale	250	500	900	1,600	2,400	3,300	4,300
Retail	4,350	5,500	8,000	12,200	19,500	29,500	40,800
FIRE 2/	700	1,000	1,400	1,900	2,900	3,900	5,500
Services	3,400	4,700	7,100	11,000	16,300	23,600	35,600
Government	8,000	10,400	13,800	19,500	27,800	38,700	51,400
Federal	4,500	6,000	7,800	11,000	16,000	23,000	31,000
State and Local	3,500	4,400	6,000	8,500	11,800	15,700	20,400
Other 3/	3,300	3,700	4,900	7,000	9,100	13,000	18,000
TOTAL	25,755	34,465	48,850	71,510	103,840	145,590	200,630

1/ Transportation, Communication and
Public Utilities.

2/ Finance, Insurance and Real Estate.

3/ Includes Self-employed, Domestic
and Household Workers.

Source: Hammer, Greene, Siler Associates.

Table 31. AT-PLACES EMPLOYMENT PROJECTIONS FOR LOUDOUN COUNTY
VIRGINIA BY FIVE YEAR INTERVALS, 1970-2000
(Projection II)

	1970	1975	1980	1985	1990	1995	2000
Agricultural, Forestry and Fishery	1,770	1,700	1,590	1,395	1,140	840	450
Construction	620	800	1,300	2,010	2,900	4,200	6,700
Manufacturing	1,000	2,000	3,500	5,200	7,200	9,300	11,500
TCU 1/	900	1,050	1,700	2,500	3,700	5,600	8,400
Trade	2,100	3,000	4,800	7,600	13,000	22,500	32,800
Wholesale	100	300	600	1,100	1,900	2,800	3,800
Retail	2,000	2,700	4,200	6,500	11,100	19,700	29,000
FIRE 2/	400	600	960	1,300	1,900	2,600	3,800
Services	2,500	3,050	4,650	6,700	9,800	14,100	19,500
Government	3,400	4,800	6,900	9,800	13,700	18,400	25,600
Federal	2,000	3,000	4,500	6,500	9,000	12,000	17,000
State and Local	1,400	1,800	2,400	3,300	4,700	6,400	8,600
Other 3/	4,400	4,800	5,600	6,600	8,000	9,500	11,500
TOTAL	17,090	21,800	31,000	43,105	61,340	87,040	120,250

1/ Transportation, Communication and
Public Utilities.

2/ Finance, Insurance and Real Estate.

3/ Includes Self-employed, Domestic and
Household Workers.

Source: Hammer, Greene, Siler Associates.

Mayor W. E. Washington

SECRETARY KLEIN: I would like to go a little bit backwards at this time instead of forwards in this, because we have Murray Grant from Mayor Washington's office, and he will be followed by Congressman Hogan.

May I ask Mr. Murray Grant from Mayor Washington's office to make his statement at this time?

STATEMENT OF

THE HONORABLE WALTER E. WASHINGTON,

MAYOR OF WASHINGTON, D. C.

READ BY

MR. MURRAY GRANT

MR. GRANT: I am Murray Grant, and I am Director of Public Health in the District. I am representing Mayor Washington, who indicated to me that he unfortunately would not be able to attend this meeting and asked me if I would present his remarks for him in his absence.

Mr. Chairman, Conferees, Ladies and Gentlemen:

May I express my personal gratification for the action taken by the Secretary of the Interior in reconvening the Conference on Pollution of the Potomac River in the Washington Metropolitan Area. The two prior sessions have identified pollution problems with which we

Mayor W. E. Washington

must deal and have been instrumental in the initiation of pollution control activities which have had a marked effect on achieving improvement in the quality of the water in the Potomac River. This Conference session will provide the opportunity to evaluate the success of our actions over the past decade and provide a pattern and guidelines for an accelerated program to protect one of our most vital resources in the Nation's Capital. We share with all of you the recognized need to protect a resource which is part of our national heritage. The Potomac River is truly the "Nation's River." I am reassured that we will succeed in this task as I note the interest of the Federal, State and local governmental agencies who are meeting with us today together with other groups, both public and private, who share with us our dedication to the improvement of the quality of the Potomac River.

In my opinion, a significant step toward the attainment of our goal of a clean Potomac River was taken by the District in the adoption of "Water Quality Criteria and Uses." These criteria, which were approved without exception earlier this year by the Secretary of the Interior, establish the goals which we hope to attain. This is the first time that we have had clearly defined

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parameters of quality to which we are firmly committed. In my opinion, the taking of this step has been long overdue since the first requirement for the solution of any problem is to identify the end results which we hope to attain. The attainment of these goals will permit the full utilization of the Potomac River and its tributaries within the District for recreational and other purposes. In addition, we shall discharge our responsibilities to our neighboring jurisdictions in assuring that the quality of the water of the Potomac River as it leaves the District will not create health or nuisance problems in the receiving jurisdictions.

I would be remiss if I did not recognize the assistance which has been received by the District of Columbia from the Federal Government in our pollution abatement activities. One of the major areas of assistance has been the provision of grant funds for the support of the construction of pollution abatement facilities. We have also received, and are currently receiving, financial support in the form of program grants which have been most helpful in the establishment of a meaningful water pollution control program by the District. We have been the grateful recipient of assistance in connection with certain

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research areas such as the work currently under way at the D. C. water pollution control facility in connection with the removal of certain nutrients from municipal waste. Last summer "Operation Clean-Waters" was supported in large measure, by the Federal Government utilizing enrollees of the Neighborhood Youth Corps. While designed primarily to clear the Potomac and its tributaries of shoreline litter and debris, the activity provided a useful opportunity for a meaningful work experience and financial return to a considerable number of disadvantaged youth within our District. This latter point is particularly important to me since I feel that sometimes we fail to recognize the social benefits which accrue as a result of activities of this type.

The problem we are discussing at this Conference is only one facet of a larger problem which exists within the District, namely, the control of environmental pollution totally. I have tremendous confidence in our technical ability to solve the problems which face us. A more difficult problem relates to the matter of finding adequate financial support to carry forward the necessary abatement actions which involve tremendous sums of money. Within the limits of fixed budgetary resources, I frequently

find myself confronted with the painful obligation to assign priorities in order to achieve the best use of these funds. While not discounting the importance of pollution abatement, we must evaluate the utilization of tax revenues and appropriations in the light of the total needs of our citizenry as it relates to such other matters as education, housing, health, welfare and related programs. I would urge that during the course of this Conference, the question of financing the cost of the necessary abatement works be given most serious consideration. Based on preliminary figures, the District of Columbia may not have the necessary financial resources to carry out its responsibilities without some form of massive Federal assistance.

May I again express my appreciation to all of you for the time and effort you are expending on a problem which is of major importance to the District of Columbia and its neighbors. I am confident that the points of view of the District of Columbia will be adequately presented by our official representatives from the Department of Public Health and the Department of Sanitary Engineering. I shall look forward to receiving your recommendations regarding the need for necessary action in the establishment of a meaningful and progressive pollution abatement program,

Congressman L. J. Hogan

and your specific suggestions for its rapid implementation. I would trust that these suggestions would clearly define the respective responsibilities of the Federal, State and local governments.

It has been a pleasure to meet with you and I wish you every success in achieving the objectives of this Conference.

Thank you.

SECRETARY KLEIN: Thank you.

I don't believe that we will have any questions of you, sir. We will wait for the official representative of the Mayor on other technical matters.

Congressman Lawrence J. Hogan, Fifth District, Maryland.

STATEMENT OF

HONORABLE LAWRENCE J. HOGAN,

U. S. HOUSE OF REPRESENTATIVES

WASHINGTON, D. C.

CONGRESSMAN HOGAN: Thank you, Mr. Chairman.

My name is Lawrence J. Hogan, and I represent the Fifth District of Maryland in the Congress of the United States.

Congressman L. J. Hogan

Maryland's Fifth District consists of Prince George's and Charles Counties, both of which border the Potomac River, and as the representative of the Council of Governments indicated, the population of Prince George's County is expanding at an extremely rapid rate. Charles County, although it is substantially rural at this time, is also undergoing an urbanization in parts of the county as the pressures from the District of Columbia, Prince George's and other jurisdictions of metropolitan Washington reach out for more land for home building. And there is no reason to suppose that this trend of increasing is going to be reversed.

The citizens of Prince George's and Charles Counties have a vital interest in the condition of the Potomac River. Both counties will be directly and immediately affected by the success or failure of efforts to save this river.

On the other hand, these two counties will also substantially affect the river as they contend with the ever-increasing demand for sewer and treatment facilities.

Now, in answer to your previous question

Congressman L. J. Hogan

to the Council of Governments representative, Mr. Chairman, the population projection for Prince George's County in 1985 is 1,600,000. At the present time our population is 600,000, so this indicates the tremendous growth which we are undergoing.

All indications are that Prince George's County will be the fastest growing county not only in metropolitan Washington, but in the Nation. Charles County's rate of population growth could be even more dramatic.

Clearly, what we need today are plans and procedures which will enable us to meet the future needs of this projected population or we will fall further behind in our efforts to establish and maintain a clean Potomac River. Conditions existing today in Prince George's County are a stark reminder of the failure to plan adequately for future development.

I would strongly recommend that the appropriate local and State officials proceed to develop a long-range plan for sewage facilities. The time to begin that planning is long overdue.

I would also like to point out that it is necessary for the Federal agencies which share the responsibility for the river cooperate with these local jurisdic-

Congressman L. J. Hogan

tions. We have been trying to get the Interior Department U. S. Park Service to give a permit for an effluent line from the Piscataway Sewage Treatment Plant, and so far we have been unsuccessful.

Now, I am sympathetic with Dr. Murray Grant when he talks about the problems of Blue Plains. We know that the three chief sources of pollution in the Potomac at the present time, according to recent studies, are the Blue Plains plant, Alexandria and Fairfax.

The problem that the Blue Plains facility has is that they are handling everyone else's sewage, and we in Prince George's County, because we are not able to officially operate our Piscataway plant, are forced to divert much of our sewage to Blue Plains for treatment. This becomes ludicrous when we realize that the Piscataway plant is discharging sewage and effluent at a much higher grade than Blue Plains is. So it seems to me that this effluent line is essential if we are going to try to reduce the pollution in the area.

I think we need plans and procedures today which will enable us to, as I say, take care of this growth, and in this planning process, all interested parties should be consulted and their expertise put to use.

Congressman L. J. Hogan

Because there are various State, county and local jurisdictions in the District of Columbia, Maryland, Virginia, West Virginia and Pennsylvania which share responsibility regarding the river, there is a need for some multijurisdictional entity which would have the authority to impose antipollution regulations on all these numerous governmental entities. The proposed Potomac River Compact would achieve this objective. I hope, therefore, that this proposal will enjoy the enthusiastic endorsement of the Nixon Administration.

The Federal Government also has a major responsibility to assist the State and local jurisdictions in their efforts to improve the conditions of the Potomac River. The Federal Water Pollution Control Act, which promises two Federal dollars for each State dollar, must be adequately funded. Within the past 20 months, the State of Maryland has committed \$100 million to sewage treatment efforts, while Federal allotments to Maryland have totalled less than \$6 million. These figures, I think, clearly demonstrate the need for an increased commitment by the Federal Government if we are ever to succeed in restoring the Potomac.

In conclusion, I want to take this oppor-

R. L. Orndorff

tunity to express my personal long-standing commitment to the goal of a clean Potomac. There is surely no reason we cannot achieve this goal. The only roadblock would be our own inability to see the consequences of failing to act now.

Thank you, Mr. Chairman.

SECRETARY KLEIN: Thank you very much, Congressman Hogan.

The next presentation will be by Mr. Roy Orndorff of the Potomac River Basin Advisory Committee.

Mr. Orndorff.

STATEMENT OF

MR. ROY L. ORNDORFF

ACTING EXECUTIVE SECRETARY

POTOMAC RIVER BASIN ADVISORY COMMITTEE

MR. ORNDORFF: Mr. Chairman, Members of the Conference, and Ladies and Gentlemen:

The Potomac River Basin Advisory Committee appreciates the opportunity to make this statement to the Conference.

The Advisory Committee was created in April 1965 by the Chief Executives of the States of Maryland,

Virginia, West Virginia and Pennsylvania and the District of Columbia to coordinate and represent the genuine interests of the States in the current Potomac Basin planning activity but, most importantly, to advise the heads of government on the best possible interstate organization to plan, develop and manage the resources of the River Basin. The Advisory Committee has pursued these assignments with great diligence and thus has significantly contributed to the promotion of comprehensive and cooperative Potomac planning with which the conferees are familiar.

In response to the Governors' assignment to advise them on the best possible resources organization for the Basin, the Advisory Committee has proposed a Federal-interstate compact commission conceived along the general lines of the Delaware and the proposed Susquehanna Commissions but carefully designed to meet the special needs of the Potomac Basin. The Advisory Committee was able to develop this Compact proposal by dint of several years of intensive study, discussions, hearings and other communication with agencies and citizens of the Basin. The Compact Commission would assume the responsibilities and the authority necessary for the comprehensive purposes specified by the Governors. The Commission would be comprised

of the Governors or their designees or appointees and a Federal member appointed by the President. Its scope would be comprehensive, yet well-defined, and would include among others the responsibility for coordination of water quality management and control. It would afford a means by which the signatories, jointly and cooperatively, could accomplish the things that are beyond their capabilities as long as they must act individually.

I don't need to tell you that the subject of this Conference - "Pollution of the Potomac River - Washington Metropolitan Area" - is not geographically indicative of many of the factors and implications of water quality in the metropolitan area. The River, its tributaries, its watershed lands, its uses, its misuses, its people, its life, taken together, constitute a system with a myriad of interrelationships. For instance, when we speak of water quality in a particular stretch of river, we understand that this is not confinable to matters like removal of a high percentage of BOD from sewage or some similar local specifics, but necessarily involves population densities, land uses, industrial activities, rainfall and run-off rates, conservation practices and many other factors operating in the drainage area above; and water supply, recreation,

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fisheries and others pertaining to the reaches below.

Recognizing this broad view of the problems of water resources, it becomes obvious that the complexities and implications are beyond the geographically-confined State and local capabilities to resolve. Nevertheless, it is essential, in our philosophy of government, that the solutions be based on State, local and citizen inputs. As an instrument to encourage, coordinate and utilize these inputs and to relate them to the substantial Federal interests and responsibilities, the Advisory Committee offers the Potomac River Basin Compact and the Basin Commission which that document contemplates. We believe it is the only available means of providing, in a reasonable balance of all the legitimate interests, those powers and responsibilities necessary for effective planning, development and management of the basin's water and related resources. In many aspects, among them water quality control in the metropolitan area and elsewhere, the needs and problems are urgent - the time is late. The Potomac River Basin Advisory Committee considers it to be of the utmost importance that the public officials and citizen leaders of the basin actively support the early enactment of the Compact by the State legislatures and the Congress.

Thank you.

SECRETARY KLEIN: Mr. Orndorff, if you would wait, please?

Do any of the conferees have questions of Mr. Orndorff?

(There was no response.)

SECRETARY KLEIN: If I may, for my own information and I think for a great many people here, I would like you to define what are your boundaries or jurisdiction. Generally speaking, how far upstream and how far downstream do you go? Do you take the whole Potomac or just part of it?

MR. ORNDORFF: No, the entire Potomac Basin.

SECRETARY KLEIN: Fine. And what is your jurisdiction for planning? Is it water, sewage, pollution, and everything else?

MR. ORNDORFF: Well, I suppose it isn't really fair to say that we have a jurisdiction for planning. We were given this assignment by the Governors when the President directed Secretary Udall to review the Corps of Engineers' plan and devise a plan which would be a model for the Nation. The Governors then came through by

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appointing this Committee to represent the States in this planning effort.

We have provided representation as observers on the sub-task force of the Federal Interdepartmental Task Force and participated in that planning and the reports which followed it, and, very importantly, we have developed this Compact of which I spoke.

SECRETARY KLEIN: Now, on this, do you go into both water supplies for this metropolitan area of Washington as well as the pollution factors that are involved herein in your planning?

MR. ORNDORFF: The Commission certainly would. Bear in mind, however, that we are not at this stage in developing a plan. We are trying to develop a mechanism for an organization which will do the planning.

SECRETARY KLEIN: I see. Thank you.

Are there any further questions by the conferees?

(There was no response.)

SECRETARY KLEIN: Thank you very much, Mr. Orndorff.

We have a statement by Mrs. Edward McNulty of the League of Women Voters Potomac Basin Inter-League

Mrs. E. McNulty

Committee. Mrs. McNulty.

STATEMENT OF
MRS. EDWARD McNULTY
POTOMAC BASIN INTER-LEAGUE COMMITTEE
LEAGUE OF WOMEN VOTERS

MRS. McNULTY: Mr. Chairman, I am Mrs. Edward McNulty, Chairman of the Potomac Basin Inter-League Committee of the League of Women Voters. This committee is made up of representatives from the 19 State and local Leagues in the Potomac Basin; 7 of these Leagues are in the Washington Metropolitan Area.

The League of Women Voters has had water resources on its national program since 1956. After study and evaluation, the League has supported overall long range planning of water resource development and the management of water resources on a river basin or regional basis. The Leagues in the Potomac Basin feel that a Federal-Interstate Compact is the only logical way to have coordinated planning and management for the Potomac River. However, we realize that the adoption of the Compact will take time and that the time for pollution abatement and control is now. Our committee wishes to commend you for reconvening

Mrs. E. McNulty

the Enforcement Conference at this time.

It is pointed out in the report prepared for this Conference that the recommendations of the 1957-58 Enforcement Conference have not been met and that at the present time the Potomac River is "grossly polluted due to inadequate sewage treatment, rapid population growth, and the discharge of combined sewer overflows and raw sewage." This emphasizes the fact that making recommendations and setting standards for pollution control and water quality are not enough. The League feels strongly that we must have treatment plants that are built for the capacity and for the degree of treatment required. We also feel strongly that localities should be required to live up to all State and Federal anti-pollution laws and water quality standards, as should the two Federal installations which are contributing to the pollution of this portion of the Potomac.

Money will be needed for new construction, upgrading of present facilities, and the elimination of combined sewer overflows. The League of Women Voters believes that there should be shared financial responsibility in water resource development. Since 1960, we have supported Federal incentives grants for waste treatment

Mrs. E. McNulty

facility construction. We have also supported the use of Federal grants to encourage States to share in the cost of waste treatment plants. This does not mean that we feel that local governments should not make a strong effort, only that in many areas local governments need help so they can have adequate sewage treatment construction.

We think that cleaning up the Potomac River should be a joint Federal, State and local effort. The Federal Government is directly involved and should contribute to the elimination of the pollution caused by the District of Columbia, Ft. Belvoir and the Pentagon. The States of Maryland and especially Virginia should put localities in the Metropolitan Potomac Area high on the list to receive available Federal grants. If the Virginia Constitution is amended to allow the State to contribute matching funds to Federal aid, this should also be taken advantage of. Maryland has a State financial assistance to sewage treatment plants program which should be utilized. Some way must be found to move more money into the construction of adequate treatment plants. Perhaps equitable user charges based on the quality and quantity of sewage treated, using Federal aid as an incentive, would encourage localities to have a rational system of payment for treatment

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facilities. However, additional funding, rather than any particular method, is our main concern.

It will not be enough to merely clean up the present pollution without taking into account what the projected population growth in this area is going to require in sewage treatment. You have not included adjacent areas such as Prince William County, Virginia, which is now considered part of the Washington Metropolitan Area, in your report. Unless adequate planning is done now, ten years from now there will be another Enforcement Conference and an even dirtier river.

League members know that the price will be high for cleaning up, and then keeping clean, this portion of the Potomac River. We think we cannot afford not to pay this price.

SECRETARY KLEIN: Thank you, Mrs. McNulty.

I may make a comment at this time: that I don't think there will be another ten-year delay between this conference and the next one. I think that the expansion of boundaries will take place in order to have a realistic viewpoint as we expand our territories of the metropolitan area into Virginia and Maryland.

Do you have any specific recommendations

Mrs. E. McNulty

on how to raise these moneys to pay for the cost of putting in sewage treatment plants and then operating them?

MRS. McNULTY: Well, we think that the Federal Government should contribute its share through the plans that have already been set up by Congress.

SECRETARY KLEIN: And State and local?

MRS. McNULTY: And the State and local governments then contribute their share, so that it is a joint effort.

SECRETARY KLEIN: Do you have any idea of how the State and local governments should raise these funds?

MRS. McNULTY: As I said in my statement, we are more interested in getting more money than in any particular method of funding.

SECRETARY KLEIN: You mean in having more money used for this?

MRS. McNULTY: Yes.

SECRETARY KLEIN: I was wondering if the League had any idea or if they had made any research to see how much of local budgets is used for these purposes now?

MRS. McNULTY: My committee hasn't. I don't know if the National League has on the national

Mrs. E. McNulty

level or not.

SECRETARY KLEIN: We are looking just in this locality.

MRS. McNULTY: No, not in this locality.

SECRETARY KLEIN: All right, thank you.

Any questions by the conferees?

(There was no response.)

SECRETARY KLEIN: Thank you very much, Mrs. McNulty.

May we have Mr. Gerald Chapin, West Virginia President of Division, Izaak Walton League? Is Mr. Chapin present?

(There was no response.)

SECRETARY KLEIN: Mr. Ivan Sims, Maryland, Chairman, Inter-division Committee on Potomac, Izaak Walton League?

(There was no response.)

SECRETARY KLEIN: Mr. Eugene Minney, Indiana, Co-Chairman, Izaak Walton League?

(There was no response.)

SECRETARY KLEIN: Mr. Ted Pankowski, Assistant Conservation Director, Izaak Walton League?

(There was no response.)

SECRETARY KLEIN: I'm sorry; the Izaak Walton League seems to have struck out this morning. I understand that three of them are not in town yet, and Mr. Pankowski will not be in until later.

Is it possible that Mr. Farrar of the National Wildlife Federation is here?

For this I apologize to the people I am calling now, but that is because the other people did not meet their commitments.

Is Mr. Farrar here at the present time?

(There was no response.)

SECRETARY KLEIN: If not, I am going to try to fill in. Mr. Dick Stroud, Executive Vice President, Sports Fishing Institute?

(There was no response.)

SECRETARY KLEIN: We have Mr. Walter Kiechel of the Department of Justice here.

Mr. W. Kiechel, Jr.

STATEMENT OF

MR. WALTER KIECHEL, JR.

ASSISTANT CHIEF, GENERAL LITIGATION SECTION

IN CHARGE OF THE WATER RESOURCES UNIT

LAND AND NATURAL RESOURCES DIVISION

UNITED STATES DEPARTMENT OF JUSTICE

MR. KIECHEL: Mr. Secretary, Conferees,
Ladies and Gentlemen:

The Department of Justice is pleased to accept the invitation to attend this conference. In addition to the functions of the Attorney General under the Federal Water Pollution Control Act generally, we have a special and continuing concern with respect to the water quality of the Potomac River.

I wish I could compliment the conferees on the progress that has been made. Unfortunately, the facts as set forth in the report prepared by the Federal Water Pollution Control Administration for this conference permit no such compliment. I am speaking of the facts presented in the report for this conference by the Federal Water Pollution Control Administration, and of the facts apparent to all who live in this area and see, feel and smell

Mr. W. Kiechel, Jr.

the Potomac.

We meet here to pursue the common goal of improving the quality of the Potomac River. We of the Department of Justice want to assist in that endeavor.

The Federal Water Pollution Control Act provides several tools for water pollution abatement, including the calling of conferences such as this conference, the calling of hearings, and the establishment of water quality standards. The Act also provides another tool - litigation. We do not mean to exalt the remedy provided the Secretary, should the other tools be to no avail, of requesting the Attorney General to bring a suit on behalf of the United States to secure abatement of the pollution of the Potomac River. We sincerely hope litigation will not be necessary. But we do mean to make it clear that we will not shirk our responsibilities to wield the tool of enforcement litigation should it be necessary.

SECRETARY KLEIN: Thank you very much.

At this point, I appreciate the positive attitude from the Department of Justice, and I think all of us here do.

MR. KIECHEL: Thank you.

SECRETARY KLEIN: Thank you very much, sir.

Mr. E. T. Jensen

At this time, if I may, I think we should be getting into the meat of the question. What is the condition of the Potomac at this time? What are the problems we face? What do we have in abatement hardware right now? What are we going to need for abatement hardware? What are we going to have to spend in the future?

At this point I call call on Mr. Jensen, our Regional Director from Charlottesville, Virginia, to put on the case of the pollution of the Potomac.

Mr. Jensen.

STATEMENT OF

MR. EUGENE T. JENSEN

CONFeree, AND REGIONAL DIRECTOR

MIDDLE ATLANTIC REGION

FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

UNITED STATES DEPARTMENT OF THE INTERIOR

CHARLOTTESVILLE, VIRGINIA

MR. JENSEN: Mr. Chairman, the Federal portion of the conference will include a series of reports by the Federal Water Pollution Control Administration and by several other interested Federal agencies.

Following these, we have planned to have

Mr. E. T. Jensen

statements presented by the interstate agencies, which we believe will then give a total picture of the pollution problem here in the Potomac and the actions and items which these agencies are now recommending.

We have four statements that we wish to present for the Federal Water Pollution Control Administration. The first of these is the summary of the report which has now been widely distributed. Secondly, we will have a brief discussion of the mathematical model which the Federal Water Pollution Control Administration has developed and applied to the Potomac. The third is a report by one of our scientists on the role of nutrients in relationship to algae in rivers, lakes and estuaries. And then, finally, we will have a statement by one of our Assistant Commissioners describing the progress which has been made in the development of the advanced systems for the removal of nutrients.

I had also requested that the Washington Council of Governments present a discussion on population trends. It seems to me also that we must be concerned with these enormous population growths.

I believe that it would be appropriate for us to defer any questions of the Federal Water Pollution

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Control Administration members until after the entire series of reports has been presented. We could, of course, do it otherwise, but I believe this would be the most effective way.

I would like to call on Mr. Grover Cook, the Chief of our Enforcement Branch, Middle Atlantic Region, to present the basic Federal Water Pollution Control Administration Report on the Potomac.

Mr. Cook.

STATEMENT OF

MR. GROVER W. COOK

CHIEF, ENFORCEMENT BRANCH

MIDDLE ATLANTIC REGION

FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

UNITED STATES DEPARTMENT OF THE INTERIOR

CHARLOTTESVILLE, VIRGINIA

MR. COOK: Mr. Chairman, Conferees, and Ladies and Gentlemen:

I am Grover W. Cook, Chief of the Enforcement Branch, Federal Water Pollution Control Administration, Middle Atlantic Region. At this time I will summarize the report, "Potomac River Water Quality, Washington, D. C.

Metropolitan Area," but request that the entire report be entered into the record.

SECRETARY KLEIN: So ordered.

MR. COOK: I will also add some information that is not covered in the report.

Much has been written about the Potomac River. It has been called the "Nation's River" in a report to President Johnson last year. If any river belongs to the Nation, the Potomac surely does. The rich history of this great river basin -- all the way from the Chesapeake Bay to the Fairfax Stone and the cool mountain streams of its headwaters -- is among the first teachings to American school children. It is also Washington's river. The drinking water that flows through pipes along most of the streets in this area comes from the Potomac. There are 4000 boat slips and an estimated 15,000 registered boats in D. C. and the Maryland and Virginia counties bordering the Potomac Estuary. Thousands of people enjoy the recreational opportunities provided by its presence even in its polluted condition. Unfortunately, it has been used for waste disposal and that is not a good place for that because the Potomac at Washington is no longer a river but an estuary where the tides cause a sort of sloshing action

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so that wastes that are deposited are not abruptly swept downstream to become someone else's problem. Wastes entering the Potomac only slowly work their way toward the Bay, their progress reversed twice a day by the incoming tides.

The area covered by the report is essentially the Upper Estuary of the Potomac from Little Falls to Hallowing Point. The data presented on water quality and waste inputs for the area were obtained from FWPCA studies from 1965 to 1967, and from information provided by other Federal, State and municipal agencies. An FWPCA report, "A technical Assessment of Current Water Quality Conditions and Factors Affecting Water Quality in the Upper Potomac Estuary," presenting water quality data for 1968, is now available.

Here is necessarily an ad lib. We had copies of this report with us when we got to the hotel last night, and we can't find a trace of them. Several boxes have disappeared. Mr. Jensen, I think, has one in front of him.

Do you, Mr. Jensen?

MR. JENSEN: Yes, I do.

MR. COOK: Will you hold that up? We can

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make these copies available to the conferees a little later. We will have to get them from our office in Charlottesville.

I might add at this time that we also have available a recent report on the bacteriological condition of the Potomac Estuary, and we will very shortly, I hope in time to submit it for the record, have the results of a bacteriological survey completed only a few days ago, and I think these findings will be very interesting.

The 1958 session of the conference resulted in a set of recommendations which was issued in the Summary of Conference by the Surgeon General on April 4, 1958. Those recommendations are reprinted on page 12 of the report, "Potomac River Water Quality - Washington, D. C. Metropolitan Area." Briefly, the Summary called for secondary treatment at all sewage treatment plants, 80 percent BOD removal, and effluent disinfection when necessary. At that time the state of the art was such that 80% BOD removal was considered high. It also recommended that the District of Columbia implement by 1966, Plan C of their Consulting Board of Engineers for control of stormwater overflows. Some of these goals were accomplished, others were not. A detailed discussion of compliance with the

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recommendations are covered from page 19 to 21 in the report. Although more than \$150 million has been invested in sewage treatment plants, pumping stations, and interceptor sewers (\$80 million in D. C. alone) since 1957, FWPCA reports from 1965 to 1968 show that the Potomac and other streams in the Washington Metropolitan Area are still polluted. The reason that pollution still exists is that construction of sewage treatment facilities has not kept pace with the tremendous population increase.

The visual signs of pollution are present in all of the streams of the area. Floating sludge masses lifted from the bottom by decomposition gasses, litter and debris can be observed. Raw sewage is found in the vicinity of combined sewer overflows during and following storms. These overflows are partly responsible for high bacterial densities and low dissolved oxygen concentrations.

The problem of floating litter and debris is being attacked by the Corps of Engineers by the use of sweeping vessels. You saw some of them yesterday. In addition, during 1968 teams of about 100 Washington youths under the sponsorship of the D. C. Government and the Neighborhood Youth Corps cleared 155 tons of debris and junk from the banks of the streams. About a dozen college boys,

part time employees of the FWPCA, supervised the job which was known as Operation Clean Streams.

Chronic oil spills create periodic nuisance conditions. Spills cause stream banks, bulkheads, piers and boats to be coated black at the water-line. There were six significant spills in the past 15 months. Causes included a pipeline break, careless handling in off-loading oil barges, and faulty equipment. A spill last month was caused by overfilling a bulk storage tank. A valve was open on a pipe used for draining water from the diked area, and the spilled oil drained to the river. In order to minimize the effects of oil spills, and to be better prepared for a major incident, the FWPCA, in cooperation with the Coast Guard, Corps of Engineers, and the Department of Health, Education, and Welfare, has prepared an oil spill contingency plan for the Potomac River. The plan is designed to respond quickly to a spill, to promote more careful handling of oil and to effect clean-ups when spills occur.

There are three major consequences from sewage discharges: high bacterial densities, low dissolved oxygen, and excessive algal growths. The bacterial and dissolved oxygen problems are greatest in the vicinity of

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the D. C. sewage treatment plant. The algal blooms are heaviest from about the Woodrow Wilson Bridge to Indian Head.

The coliform bacteria counts during a three-month survey in 1965 averaged 521,000 per 100 ml. This is 500 times the standard for water contact sports such as swimming and water skiing, and 100 times the standard for partial body contact activities such as fishing and boating. More recent surveys by the FWPCA reveal: total coliform about 200,000/100 ml, fecal coliform 100,000/100 ml, and fecal streptococci 5000/100 ml. The latter is considered important because it is evidence of human fecal pollution. Salmonella, disease-causing bacteria, were found in almost all areas where high coliform bacteria counts occurred.

Sewage and other organic wastes decompose through bacterial action and chemical oxidation. In the process dissolved oxygen (DO) is extracted from the water where the decomposition occurs. This organic material under decomposition exerts what is known as a biochemical oxygen demand (BOD). The stream is capable of absorbing limited amounts of oxygen from the atmosphere but when the BOD is great enough the DO is reduced to levels that will not support fish and other aquatic life. During the

1965 survey the DO in the Potomac upstream from Washington was about normal at 7.4 mg/l. About three miles above the D. C. sewage treatment plant, the DO had dropped to 5 mg/l and was 3 mg/l near the plant. The lowest value for the survey was 0.4 mg/l near the point of discharge from the D. C. plant. DO values as low as 1 to 4 mg/l were recorded all the way to Hallowing Point. Similar conditions were found in the 1968 surveys. Only rough fish like carp and catfish and pollution tolerant aquatic organisms such as sludgeworms can exist under these conditions.

The algal blooms that occur during the warm months are particularly serious because they not only are unsightly but they are an indication of an extreme imbalance in the ecology of the estuary. These intense growths are a manifestation of sewage pollution and are pollutants themselves when they die-off and decay. The microscopic green plants that comprise the bloom require nutrients for growth just as do green plants on the land. On land a pound of fertilizer grows so many additional pounds of grass. The fertilizer-growth relationship in water is similar. All of the elements necessary for plant growth are contained in sewage. When the water is fertilized by sewage the algae, which are normal inhabitants of surface

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waters everywhere, increase in numbers. If enough fertilizer or nutritive material is applied the standing crop of algae will reach nuisance proportions.

The conventional sewage treatment plant is capable of removing most of the organic materials before discharge, and the bacteria can be destroyed by disinfection, but only a small percentage of the nutrients is removed. Nitrogen and phosphorus are the two plant growth nutrients implicated in algal blooms. It is estimated that phosphorus in the raw sewage of the Washington Metropolitan Area totals 21,100 pounds per day. Recent studies indicate that 55,000 pounds of nitrogen per day are contained in wastewater discharges.

The sediment load to the estuary is an important consideration of the overall problem. On page 25 of the report is a table that gives the estimated annual yield of sediment in the entire Potomac Basin. About 29% of the average yield is from the area covered by this conference. Out of the total annual yield for the entire Potomac Basin of 2.5 million tons per year, about one-fourth is from the area around Washington. Only 4% is attributed to the area downstream from Washington.

Although the areas upstream and downstream

receiving stream to such degree as to create a nuisance, or that interfere directly or indirectly with water uses."

The job of cleaning up the Potomac is not an impossible one. Technology now exists for the treatment of the wastes to remove the objectionable materials that cause the conditions that exist in the Potomac. To meet Federal and State standards and to enhance water quality in the Potomac River Estuary in the Washington, D. C. area, it is recommended that:

1. Waste treatment facilities be provided and maintained to ensure compliance with water quality standards. Meeting these standards at present waste loads and discharge locations -- and I emphasize present waste loads and discharge locations -- requires a 98 percent reduction in raw sewage fecal coliform densities, and a 96 percent reduction in 5-day 20 degree C BOD with a maximum total discharge of 16,500 lbs/day BOD₅.

2. Phosphorus reduction facilities be provided for all waste discharges to the Potomac Estuary to prevent excessive algal growths. Meeting this recommendation at -- and this is underscored again for emphasis -- present waste loads and discharge locations requires a 96 percent reduction in total phosphorus (P) from 'all

sources.

3. An evaluation be made of the feasibility of discharging effluent from the District of Columbia Water Pollution Control Plant through several outlets along the Estuary rather than through the existing single outfall. Water quality advantages of multiple outlets should be assessed because these may indicate that reductions are possible in the extremely high removal percentages that are otherwise necessary for specific waste constituents. Before discharge all wastes must receive the highest degree of treatment practical, including phosphorus removal.

As waste loads increase, the degree of treatment provided by all plants must be such that the quality of the receiving waters, including the Estuary and the tributaries thereto, is maintained within the requirements of the applicable standards.

4. Completion of the District of Columbia's revised Plan C for the elimination of combined sewer overflows and raw sewage diversion to the Potomac and Anacostia Rivers and Rock Creek be achieved as rapidly as feasible, with especial reference to advancement of the completion date insofar as possible for eliminating raw sewage dis-

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charges.

The State of Maryland take action to eliminate the pollution entering Rock Creek and the Anacostia River upstream from the Maryland-District of Columbia line.

Alexandria, Virginia, undertake a program commensurate with that of the District of Columbia for control of few sewage discharges through combined sewer overflows and diversions.

5. Existing local, municipal, county, State, interstate, and Federal agencies involved in erosion and silt control unite in an expanded, coordinated effort to implement the 10-year accelerated silt control program for the Potomac River Basin including the Anacostia River and Rock Creek that was recommended by the Sedimentation and Erosion Sub-Task Force.

Seneca Dam and Reservoir site be preserved at its present level of economic development in accordance with the recommendation of the Potomac River Basin Advisory Committee and the Federal Interdepartmental Task Force in their report, "Potomac Interim Report to the President."

6. A systematic program be developed and conducted to prevent the disposal of trash, debris, junk, and other objectionable material adjacent to and into

waterways. "Operation Clean Waters," a cooperative effort between the government of the District of Columbia and the Federal Government utilizing enrollees of the Neighborhood Youth Corps, is an example of the type of cooperative program needed.

MR. JENSEN: Thank you, Mr. Cook.

SECRETARY KLEIN: Mr. Cook, that was comprehensive, and it is quite an indictment of the condition of the river.

Fellow conferees, I will ask you whether you have any questions of Mr. Cook at this time, starting on my left?

MR. JACKSON: Mr. Chairman?

SECRETARY KLEIN: Yes, Mr. Jackson.

MR. JACKSON: I would like to ask Mr. Cook this question. On page 3, it reads: "The reason that pollution still exists is that construction of sewage treatment facilities has not kept pace with the tremendous population increase."

This seems to imply that the pollution is due only to waste treatment plants, but bear in mind that the high BOD values are certainly a polluting effect of simply street runoff.

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Do you consider this is really the only reason for the continuation of pollution?

MR. COOK: Oh, no, sir. We all are aware, of course, of pollution from urban runoffs, and certainly it is a consideration that must be taken into account.

We have good information, of course, on the construction of sewage treatment plants. I think our information on the contribution from runoff is somewhat more lacking.

MR. JACKSON: Thank you.

SECRETARY KLEIN: Any other questions on my left, gentlemen?

(There was no response.)

SECRETARY KLEIN: On my right?

MR. JOHNSON: Yes, Mr. Chairman, I have a question. In fact, I have two questions.

Mr. Cook, on Page 4 you make reference to the three months survey in 1965. We all know that the year 1965 was close to the end of one of the most serious drought periods in the history of the Potomac River.

Is this the latest information that you have? This doesn't seem to me to be a particularly good year on the drought conditions to recite DO concentrations

and all that.

MR. COOK: No. Mr. Johnson, the report that I mentioned contains that information and will thoroughly update the information.

MR. JOHNSON: That will update the information?

MR. COOK: Yes, it does.

MR. JOHNSON: Mr. Chairman, I would like to request that at the proper time this new and updated information be read into the record.

SECRETARY KLEIN: I will be glad to do so. If we can find it in the interim, I would rather get it in during the public hearing tomorrow. We will see whether we can do so because I would like to have it in there.

Actually speaking, I will advise you that I asked that it be updated in the last several weeks so that we would have up to date information and not older information available for the conference.

MR. JOHNSON: Thank you.

Now, I have one more question. On page 6 you make reference to the Federal Water Pollution Control Act of 1965 and the water quality, and you go on to say that the standards are being violated. I question whether

G. W. Cook

this is really a fair statement. I believe that the implementation plans are a part of the standards.

Is this not correct?

MR. COOK: That is correct, yes.

MR. JOHNSON: And the standards were adopted in the District of Columbia less than six months ago, I believe, and I question whether they are actually in violation.

MR. COOK: I think they are in violation to the extent that the criteria are being violated. The values of the bacteria, of course, are many times the standards for these approved uses.

MR. JOHNSON: But they are not in violation as far as the implementation of the standards?

MR. COOK: No, sir, not to my knowledge.

SECRETARY KLEIN: Of course, the point that you make, Mr. Johnson, is that although you have gotten into it with the river polluted, you are acting to dispose of this pollution problem.

MR. JOHNSON: Yes.

SECRETARY KLEIN: If I may put it so very shortly.

MR. JOHNSON: Yes.

G. W. Cook

SECRETARY KLEIN: I think that is where your question was directed.

MR. JOHNSON: Yes.

SECRETARY KLEIN: Mr. Hope had a question, and I missed him before. Mr. Hope.

MR. HOPE: Mr. Cook, on page 4, admitting to the accuracy of your statements regarding the bacteriological quality of the river, I think we have to recognize the fact that the river, in spite of the fact that it does not meet the established criteria, is still being used for recreational purposes to some limited extent.

Have your findings been able to uncover any specific health problems that have arisen as a result of such recreational use?

MR. COOK: No, I have seen no information in that regard.

MR. HOPE: And then on page 6 I find reference to and the use of the word "nuisance." I must confess that this is a term that has little in the way of specific meaning as it relates to my understanding of what nuisance situations are.

Am I to understand from your statement here that the growth of algae is automatically considered

G. W. Cook

as being a nuisance in any given body of water?

MR. COOK: Very definitely, yes, sir.

MR. HOPE: All right, thank you.

SECRETARY KLEIN: Mr. Jackson, you had another question?

MR. JACKSON: Yes. Thank you, Mr. Chairman.

Mr. Cook, would you be of the opinion or would you think it desirable, even with advanced waste treatment, to disperse waste treatment plant effluent at various stages down the Potomac River?

I am referring to your third item on page 7, that "An evaluation be made of the feasibility of discharging effluent." Recognizing that this effluent, if it is treated by the advanced waste treatment processes, will be a very, very highly purified effluent, would it warrant the additional expense of distributing that effluent?

MR. COOK: That, of course, would be part of the study.

I would like to go back just a moment, if I may, to Mr. Hope's question. I don't think I answered that quite correctly. I saw a grin on his face, as if he believed I answered wrong.

The question, as I think it was stated, was: Would you consider algae a nuisance in any body of water? Was that about it, Mr. Hope?

MR. HOPE: That's about it.

MR. COOK: Of course, we are talking here about great concentrations of algae causing nuisance.

MR. HOPE: In other words, you are using the word "nuisance" in a relative sense. The definition of what level will constitute nuisance is still something to be determined?

MR. COOK: Yes.

MR. HOPE: Thank you.

SECRETARY KLEIN: Mr. Paessler.

MR. PAESSLER: The recommendation with respect to the degree of removal of coliform organisms and BOD on page 7 specifies the maximum total discharge as 16,500 pounds per day of BOD, and this is preceded by the underlined statement previous to that, on the basis of "present waste loads and discharge locations."

Is 16,500 pounds the maximum amount of BOD consistent with meeting the standards that can be discharged to an estuary? In other words, does this mean that as population grows, BOD removal from sewage and

other waste sources will have to be jacked up to a higher degree than this report contemplates?

MR. COOK: Yes, sir. That is why it was emphasized.

MR. PAESSLER: Therefore the 96 percent reduction in 5-day BOD based on present discharges to meet this 16,500 would not last too long in the future?

MR. COOK: Well, from what we heard about population projections for this area this morning, certainly it wouldn't seem so.

SECRETARY KLEIN: Yes, Mr. Hope again.

MR. HOPE: One final question: In the report that has been prepared as background for this particular conference, no reference has been made to the matter of possible flow implementation of the Potomac River.

This is part of the overall plan. I think those of us in the District are particularly concerned as it relates to the need to supply adequate quantities of raw water for domestic water purposes within the District itself.

If there is a meaningful program of flow implementation established, wouldn't it mean that there might be some change in the figures which you are quoting

G. W. Cook

in your report as it relates to the absorptive capacity in particular of the Potomac River?

MR. COOK: I am in that unique spot of being a biologist answering a pretty tough engineering question. You may have somebody in our group that could answer that, or perhaps Mr. Jensen could, but I don't feel qualified to.

MR. JENSEN: I think perhaps Dr. Hetling's paper would answer that. Perhaps we might ask that that be held until after Dr. Hetling has spoken.

SECRETARY KLEIN: Would you hold that, Mr. Hope?

Mr. Jackson.

MR. JACKSON: One final question.

SECRETARY KLEIN: Let's not make them final. What we are doing is asking more and more questions and, if I may say, that is what I would like to have everybody do, because I would like to get to the meat of it.

MR. JACKSON: Thank you.

Mr. Cook, on page 8 you say: "Completion of the District of Columbia's revised Plan C for the elimination of combined sewer overflows and raw sewage diversion to the Potomac and Anacostia Rivers and Rock Creek."

G. W. Cook

Is this reference to raw sewage diversion included in the combined sewers, or are you referring to separate raw sewage diversion?

MR. COOK: I can't answer that question.

MR. JACKSON: I might just comment, Mr. Chairman.

SECRETARY KLEIN: If you will, please.

MR. JACKSON: That there is a recommendation that projects be completed as rapidly as feasible. I think the District has done that as rapidly as feasible, and the only reason we have not been able to complete it is because of rights of way beyond our control.

In other words, we have to schedule that completion along with highways and other construction within the District, and this has been entirely beyond our control.

Thank you, sir.

SECRETARY KLEIN: Thank you.

Mr. Cook, according to the general statement you made to begin with, we are now to consider the Potomac not as a river but as a lake which doesn't move except by the action of the tides. Is that about right?

MR. COOK: Well, of course there is an

oscillating movement of water bayward. It behaves less like a river and more like a bay as you go towards the ocean.

It is a very complex thing. An oceanographer perhaps could put it in simple terms and be understandable, but it isn't exactly a lake because this water does move out eventually into Chesapeake Bay and into the ocean.

SECRETARY KLEIN: But, generally speaking, what we put into the Potomac River here stays here for quite a period of time?

MR. COOK: It stays here many, many days, yes, sir.

SECRETARY KLEIN: All right, so we will get an idea as to why we have these bacteriological conditions.

I asked Mr. Jensen a question on the side, and he tells me that in 1958 we had about ten times as much, 160,000 BOD, we thought could be handled by the Potomac at that time. Is that correct, or do you know?

MR. COOK: I don't recall that exact figure, no, sir.

MR. JOHNSON: 120,000.

SECRETARY KLEIN: 120,000 pounds BOD.

G. W. Cook

Now, it is obvious from your report, is it not, that we have to draw the conclusion that we can't take 120,000 pounds per day?

MR. COOK: Absolutely, that is correct.

SECRETARY KLEIN: And the results that we now have in the Potomac are due to the fact that we had an erroneous, or maybe we didn't project far enough in advance the amount of BOD that we were going to put into the Potomac every day, so now we've got troubles because we projected it far too high?

MR. COOK: That's correct.

SECRETARY KLEIN: One of the things that bothered me--and if I may hit this one right here and now and I have asked Mr. Jackson and also Mr. Jensen to check on this--is that we get a water supply from the Potomac River, and there are statutes to protect it for 50 miles upstream so that the Washington, D. C. area gets good water, and somebody issued a permit for an aluminum plant 51 miles upstream.

We have asked them to report. Mr. Jackson is checking and Mr. Jensen is checking to see whether or not the effluent from this aluminum plant is going to affect the water supply coming to the City of Washington,

D. C.

With your permission, gentlemen, the reports that I get from both of these gentlemen will be added in the Summary of this conference.

On control of storm overflows, this is one of the questions I have always asked in the past: How many separate systems do we have of storm sewers and sanitary sewers in the area? Does Washington, D. C. have any?

MR. COOK: They would be best qualified to answer that, Mr. Chairman.

SECRETARY KLEIN: Do you know whether any of the suburbs around here have separate or storm sewers, storm and sanitary sewers?

MR. COOK: Yes, I think that all of them have.

SECRETARY KLEIN: And Washington, D. C. probably does not, because it was built before we achieved this concept?

MR. COOK: I imagine some of the newer suburbs are in pretty good shape as far as separate sewers are concerned.

MR. STEIN: Alexandria has a combined system, I believe.

G. W. Cook

SECRETARY KLEIN: Mr. Cook, do you have any idea how many sewage treatment facilities have been built in the last ten years since 1958 in this area?

MR. COOK: Well --

SECRETARY KLEIN: Or is this something that will come later, Mr. Jensen?

MR. COOK: I could probably answer that if I could dig for the information. As you probably know, you and I were fighting the battle of Lake Michigan, and I am not really too familiar with these things down here, so I can't answer that off the top of my head.

MR. JENSEN: A major portion has been expanded in the D. C. area, and Mr. Jackson will have a complete statement on the steps that they have taken in the past ten years.

SECRETARY KLEIN: I will reserve this question then, if I may.

MR. McKEWEN: Could I make one brief comment? You mentioned the aluminum plant in Fredericks County, and I think it might be appropriate at this point not to go into detail, but discuss this briefly.

I am not sure what you meant by the 51 mile discharge was one mile above the 50 mile limit.

SECRETARY KLEIN: One mile above the 50 mile limit.

MR. McKEWEN: But there has been a proposal on the aluminum plant. There will be some wastes generally. There have been submissions at this point which are not final, no permit has been issued, and the company has been told that they must reduce fluorides to the point that there will be no effect in the stream at the point of discharge. There must be no discharge of fluorides where it will affect downstream water supply.

SECRETARY KLEIN: Fine. Thank you very much.

Mr. Cook, I had heard when I first came to Washington that about 90 percent of the pollution factor in the Potomac was from treated human wastes. Do you know whether or not that is correct?

MR. COOK: Yes, sir, I think that is about right.

SECRETARY KLEIN: This is due to the lack of industry in the area?

MR. COOK: Very little industry, as you know.

SECRETARY KLEIN: How much of the other

10 percent comes from siltation and the break-up of the silt, with carrying herbicides, pesticides and fertilizer?

MR. COOK: You are talking of BOD loading, bacterial pollution?

SECRETARY KLEIN: Yes, and pollution.

MR. COOK: The biggest problem that we have in the Potomac upper estuary with pollutants from upstream is sedimentation. The bulk of the sedimentation, approximately 70 percent of it, comes from upstream. The other forms of pollution, such as BOD and bacteria, are practically all of local origin.

I should add also that the algal crops that are developed by the nutrients do ultimately exert a BOD and in a sense are also pollutants, almost entirely from this source, but there are still rather high concentrations of nitrogen and phosphorus in the incoming fresh water river to the estuary.

SECRETARY KLEIN: In other words, we are picking up quite a bit of that from farm pollution as well?

MR. COOK: Yes, sir.

SECRETARY KLEIN: From upstream?

MR. COOK: Yes.

MR. JENSEN: Mr. Chairman, this information is also included in the supplemental report which Mr. Cook indicated we had lost somewhere in transit.

SECRETARY KLEIN: You know, while you and I were fighting the battle of Lake Michigan we got into the sanitary and ship canal. About ten years ago, if someone fell in there we would send him to the hospital for two weeks. Today, if he falls in there we just give him a shower and put him back to work.

How good is the swimming in the Potomac River? What do we have to do with somebody who falls in there?

MR. COOK: Well, if it were my son, I would disown him probably. But, seriously, the Potomac is a hazard for swimming because of the bacterial pollution.

SECRETARY KLEIN: Would you recommend that that party be placed in a hospital, or be given a physician's examination, or just a shower to come out of it?

MR. COOK: Well, I overheard Dr. Lear, our chief scientist, tell a newspaper reporter yesterday that many of the people working on boats out here do use a bacteriocidal agent to wash their hands with after they have had them in the water; and if they don't, they should.

SECRETARY KLEIN: I see. Maybe we can get Dr. Lear later to give us a further comment, Mr. Jensen.

MR. JOHNSON: I am interested in the statement that you made with regard to the law which protects them from upstream.

SECRETARY KLEIN: I will be glad to go over it with you later.

MR. JACKSON: Mr. Chairman?

SECRETARY KLEIN: Yes, Mr. Jackson.

MR. JACKSON: May I interject a bit of levity with respect to your question a little while ago about washing people off?

I received a call from a skin diver who had been regularly diving off Haines Point, and he was complaining a little bit of some trouble with his ears and his nose. He wanted to know if I thought this might be due to pollution in the area, and I told him I thought well it might. But he said he had been doing it for two and a half years, and when he found out that there was pollution there, he said he thought maybe he would move downriver a bit. So this fellow has been swimming, certainly in a sense, for quite a time in the Potomac River water. That was about two and a half years ago, so that,

answers your question.

SECRETARY KLEIN: Mr. Stein has a comment.

MR. STEIN: You know, Norm, I'm not quite sure about that.

I grew up in New York. As kids, we used to swim in the Gowanus Canal and the East River, and I always had the feeling that we developed immunity to that or we didn't survive.

What I have found in going around and investigating cases of pollution is that whenever I am up in the New York area I feel fine, but with all the other people who do the investigating, we have a disease like you do when you get into a foreign country called "La Tourista," and they get it, and when I get into other areas of the country I would get it. So, at least, from my experience I have the feeling that this immunity may be localized indeed.

But when you talk about the health hazards of the Potomac, I think possibly the bacterial counts have been reduced, but no one, with counts such as we have here, I think could safely tell anyone to go swimming in the river. I don't think you would recommend that for our children.

G. W. Cook

MR. JACKSON: I wasn't offering that in that sense, Murray. I said I would add a bit of levity. But I could also cite the Ganges River. This constant innoculation of local pollution is certainly a factor. The average life of the Indian, as you know, is considerably shorter than the average life of the American.

SECRETARY KLEIN: If I may, I would like to get an idea from you about this: You have gone over the 1958 results, the 1965 results and your recent results. Have we been moving forward or have we been slipping backwards on pollution factors in the Potomac?

MR. COOK: There was just handed to me by Mr. Jensen the results of the bacteriological survey from March 24th to April 4th. I haven't had time to analyze these, of course, but at a glance they look a little lower than the 1965 data, and I think this is true of the data that we have presented in the missing report.

I think probably there is better disinfection being effected, and there certainly has been a better, more efficient operation of the Blue Plains Treatment Plant in recent years, I believe, so I think there has been an improvement.

SECRETARY KLEIN: All right.

MR. COOK: Incidentally, if you would care to have these more recent data entered into the record, they are available. Don has scratched a note on here: "More data coming."

SECRETARY KLEIN: Fine. We will put them into the record when you have them.

MR. COOK: All right, fine.

SECRETARY KLEIN: You used the terms 98 percent, 96 percent, and so on. What does this mean to the average layman? This is on page 7.

MR. COOK: Yes. These constituents of the sewage are present, of course, in certain concentrations. What we are saying here, very simply, is that we must remove 98 percent of the -- what was it -- coliform bacteria, fecal coliform?

SECRETARY KLEIN: Fecal coliform.

MR. COOK: 98 percent of those many millions or thousands or whatever we are getting from the sewage must be removed in the process of treatment. We are saying that 96 percent of the organic material, the material that exerts the BOD, must be removed. We are asking for a pretty clear effluent.

SECRETARY KLEIN: That ties in with

G. W. Cook

phosphorus removal, as you and I know.

What kind of operation does this mean, primary, secondary, or further?

MR. COOK: This means advanced waste treatment.

SECRETARY KLEIN: And what kind of advanced waste treatment is available today to do this?

MR. COOK: One of the papers that will follow is by Dr. Stephan, who will go into that.

SECRETARY KLEIN: I will hold it until then and we will take it up with Dr. Stephan, if I may.

In other words, we have to go beyond secondary treatment?

MR. COOK: Yes, sir.

SECRETARY KLEIN: It would be your opinion also that we have to go far beyond it if we are going to support 7.7 million people in this area?

MR. COOK: We are going to have to go to a very high degree of treatment.

SECRETARY KLEIN: This is one of the points I continually have stressed, that science is just starting to catch up with this problem. Do you think we have any chance for a scientific breakthrough to get this thing

G. W. Cook

done more efficiently and especially more feasibly? This is talking economics now.

MR. COOK: I think so; yes, sir. I think so.

We have heard this from our people at the Lake Michigan conference. I believe what they said. The last year has even moved faster, and I think Dr. Stephan can shed a lot more light on it than a year ago.

SECRETARY KLEIN: I would say to the conference here that the Metropolitan Sanitary District in Chicago is going to tertiary treatment by filtration by stages out there, and they have to, because we send it downstream and Peoria drinks it. It is a pretty sad situation, and this is what we are getting into all over the country -- that we have to clean it up or we have to live with it. There are just too many people.

On revised Plan C, we have already heard from Mr. Jackson. On the several outfalls, would you detail why you think extra outfalls are necessary instead of the one major one?

MR. COOK: The point of discharge now is at the Blue Plains plant, which is in a pretty bad place because of the tidal action of the estuary. In other

words, what goes in there kind of sloshes back and forth and doesn't move on out like it would in the Mississippi River or the Detroit River or someplace like that.

Consequently, there is a DO sag or an area of low dissolved oxygen from the point of discharge on down towards the bay.

Some of our engineers feel possibly if we could kind of distribute this so that it would not all be discharged at one point, we might have an advantage, but this is merely a recommendation for a feasibility study.

SECRETARY KLEIN: In other words, you are not absolutely sure that two or three outfalls would do the job better than the major one?

MR. COOK: No, I am not at all sure.

SECRETARY KLEIN: If we got 96-98 percent removal there, would it be necessary to have more than one outfall?

MR. COOK: I don't think there would be any necessity at all for distributing it.

SECRETARY KLEIN: In other words, that would be an alternative?

MR. COOK: Yes, sir.

SECRETARY KLEIN: All right. Thank you

very much. Any further questions?

MR. PAESSLER: I want to get back to this percentage removal. Of course, that percentage removal, as I see it, is tied into present discharges, and to make this percentage removal in both phosphorus and BOD would give a satisfactory river for the present and perhaps for the future.

I am still concerned about the tremendous projections of population that we face here and the fact that facilities for the effectuation of what is being recommended here certainly are going to be expensive and they are going to incur technology and approaches that we are going to be watching, and some of the efficacies which we don't know too well now.

I am wondering whether it wouldn't be better to tie requirements of the river into specific poundages of discharge of the nutrients rather than to tie them into percentage removals, because as the loads of population increase, the percentage of removal will remain the same and this will permit more nutrients and BOD to get into the river, and, as a result, the situation in the river is going to slip up on us as it has in the past.

G. W. Cook

MR. COOK: Yes, I suspect you are right.
That is why we emphasize --

SECRETARY KLEIN: If I may, what you are talking about is a technical item between two biologists here. Which way is a better way of expressing what you want in quality, whether you say 96-98 percent, or whether you tie it into poundage?

MR. COOK: Pounds per day of loading, yes.

SECRETARY KLEIN: Which is the better?

MR. COOK: Being a biologist, I am not going to say which is better. Mr. Paessler might give you a better idea than I can, and he is not a biologist.

SECRETARY KLEIN: Mr. Paessler, may we have your comment?

MR. PAESSLER: I would say expressing it in terms of pounds, which is translatable into concentration in the river, and on which presumably you would project what is going to happen in the river would be the preferable way of expressing this.

SECRETARY KLEIN: In other words, the 16,500 that he has in this would be better than the 96 or 98?

MR. PAESSLER: Yes, and that represents

96 percent of what is being generated by how many millions there are now. 96 percent of 7.7 million or even an intermediate figure is certainly going to be more than 16,500.

SECRETARY KLEIN: And they think it is 3 million today, and 6 million would give us 33,000 pounds, which would be twice as much as we think is necessary.

In other words, you have said it as an absolute figure instead of a percentage figure.

MR. PAESSLER: Yes. The pounds of BOD in the estuary are the controlling factor, and the percentage removal is based on a particular population.

SECRETARY KLEIN: I should think that from what little I know of it, and I have learned it all from people such as you, Mr. Paessler, and Mr. Cook, we are using 96-98 because that is what we are getting over towards now in tertiary treatment, and since that is what we are bound to by the treatment, we have kind of used it as a gauge today.

Is that about the gist of it? In other words, if we have 16,500 that we can get to today, we are not so sure we can do 16,500 for twice as many people yet? Is that about correct?

MR. PAESSLER: Well, the available technology--

G. W. Cook

SECRETARY KLEIN: Excepting at high cost.

MR. PAESSLER: The available technology certainly comes in there. There is a limiting factor at the present time, I think.

SECRETARY KLEIN: Fine. Any further questions from the panel?

MR. HOPE: I have one final question.

SECRETARY KLEIN: Yes, Mr. Hope.

MR. HOPE: One final question, Mr. Cook: I think some of us are moderately disturbed at the element of costs and the fact that finally the taxpayer is the one who is going to be paying for the cost of the facilities to go in.

With particular reference to Item Number 2 on page 7, we talk about the matter of phosphorus reduction. Do we have good assurance that if the level of reduction which you are suggesting is in fact met, that this will prevent excessive algal growth?

You have made reference in your presentation to the fact that there is a certain natural phosphorus content of the waters as they come into the District, and I am a little bit confused, frankly, as to whether the efforts that we might put forward in the way of tertiary

treatment to reduce levels of phosphorus and nitrogen will in fact prevent these unhappy growths of algae in the river.

MR. COOK: In my opinion, certainly, yes.

MR. HOPE: Thank you.

SECRETARY KLEIN: Are there any further questions?

(There was no response.)

SECRETARY KLEIN: Thank you.

(The following documents were submitted by Mr. Cook for inclusion in the record.)



POTOMAC RIVER WATER QUALITY

WASHINGTON, D. C.
METROPOLITAN AREA

FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
U. S. DEPARTMENT OF THE INTERIOR

1969

Prepared by
Technical Advisory & Investigations Branch
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SUMMARY

This report reviews the status of water quality in the Potomac River estuary approximately one decade since a Federal Enforcement Conference was conducted on pollution of interstate waters of the Potomac River in the Washington Metropolitan Area. Sessions of the Conference were convened on August 22, 1957 and February 13, 1958.

The conferees, representing the Federal Government, the District of Columbia, and the states of Maryland and Virginia, recommended that:

1. The District of Columbia accomplish by 1958 disinfection of sewage when necessary and 80 percent reduction of biochemical oxygen demand (BOD) in sewage reaching the treatment plant, that that degree of reduction be maintained, and that plans for additional treatment as needed be made far enough in advance so that the District plant would not again become a significant source of pollution to the Potomac River.

2. The Virginia communities (Alexandria, Arlington, and Fairfax County) provide treatment commensurate with that of the District.

3. The District implement, by 1966, the recommendations of their consulting Board of Engineers (Plan C - except for the Rock Creek interceptor) for control of stormwater overflows.

Six of the nine major sewage treatment plants met the recommendations of the conferees that 80 percent BOD removal be accomplished. The District of Columbia (71.2 percent), Alexandria, Virginia (76.2 percent), and Fairfax County, Virginia's Westgate Plant (49.8 percent) failed to meet the conferees' recommendations. These three plants currently account for 94 percent of the BOD load discharged to the Potomac River.

Effective disinfection of treated discharges, as recommended by the conferees, was not accomplished.

The District has made commendable progress in implementation of a revised Plan C for control of raw sewage discharges, but the recommended schedule of completion by 1966 was not met. Control of 39.6 percent of the raw sewage discharge has been accomplished and another 38.3 percent is now scheduled for control by 1969. Separation of the combined storm and sanitary sewers in progress that accounted for

22.1 percent of the total discharge is not scheduled for completion before the year 2000.

Despite the advances, the Potomac River Estuary in the Washington Metropolitan Area remains grossly polluted due to inadequate sewage treatment, the rapid population growth, and the discharge of combined sewer overflows and raw sewage.

Extremely high densities of bacteria from sewage posed a threat to the health of all those who came in contact with the water of the river.

Decomposing organic matter in the water and sewage sludge deposits on the bottom of the river reduced the dissolved oxygen (DO) content of the river to levels that would not support a sport fishery. Near the point of the District of Columbia treatment plant discharge, the DO has been so low that it would not support even the most tolerant pollution-resistant rough fish, such as carp and catfish.

Clean-water bottom organisms that serve as food for fish have been replaced by pollution-tolerant forms that are not suitable for fish. The sludge deposits have blanketed fish spawning grounds and destroyed the bottom aquatic life on which fish feed. In areas along the margins of the estuary, sludge deposits released obnoxious odors when uncovered at ebb tide. Floating sludge masses, lifted by gasses of decomposition, added to other debris on the water's surface.

Repulsive debris, including solid materials from raw sewage, defiled the surface of the estuary in the vicinity of combined sewer overflows during and following periods of rainfall. These overflows also contributed to bottom deposits, high bacterial densities, and low DO concentrations.

Nutrients from upstream sources added to those in sewage treatment plant discharges to the estuary supported excessive growths of algae. These minute suspended plants may turn the water green, add to DO depletion problems and cause fish kills and offensive odors. The filamentous forms may litter bathing waters and beaches with slimy masses and also produce obnoxious odors. Special treatment to reduce phosphorus in sewage plant effluents can control excessive algal growths.

Silt from both upstream and the urban area was a major problem. The clarity of the water was intermittently diminished, reducing the scenic

attractiveness of the river. Fish spawning grounds and fish food bottom aquatic organisms have been destroyed. It has been calculated that the 60,000,000 cubic feet (2,500,000 tons) of silt reaching the Potomac estuary annually could fill the estuary to the surface from Chain Bridge to Fort Foote in 50 years. A basin-wide cooperative program would be necessary for control of silt pollution. A program that would reduce silt reaching the estuary by 45 percent at an estimated cost of \$250,000,000 has been recommended.

Storm water drainage and raw sewage overflows and leakage from adjacent sewers to Rock Creek caused bacterial pollution that was a hazard to the health of those who came in contact with the water, and have destroyed much of the aesthetic appeal of this stream that should be one of the major attractions of the National Park through which it flows.

The Anacostia River had much in common with Rock Creek. The sources of its pollution were similar. To the problems of excessive bacterial pollution and loss of aesthetic appeal that occurred in Rock Creek, the Anacostia has added that of extremely low DO.

Since the last session of the Enforcement Conference, the Federal requirement for water quality standards on interstate streams has been established. The Maryland standards for the Potomac River and Rock Creek have been approved by the Secretary of the Interior. The District of Columbia standards have been approved, but with exceptions on certain constituents.

Pollution of the Potomac River violates the Maryland standards in several ways.

1. Estimated fecal coliform bacterial densities are far in excess of the standard limit of 240 per 100 ml.

2. The average DO of 2.8 mg/l is well below the standard of 5.0 mg/l and the minimum DO of 0.4 is even further below the standard of 4.0 mg/l.

3. Substances from sewage have settled to form sludge deposits that are "unsightly, putrescent or odorous to such a degree as to create a nuisance, or that interfere directly or indirectly with water uses."

4. Floating debris and other materials from sewage have been "unsightly to such a degree as to create a nuisance, or interfere directly or indirectly with water uses."

5. Deleterious substances from sewage have been "harmful to . . . aquatic life."

Sewage treatment plants in the metropolitan area that have been responsible for pollution of the interstate waters of the estuary include those of:

*District of Columbia
Alexandria, Va.
Arlington County, Va.
Fairfax Co., Va. (Little Hunting Creek,
Westgate, Dogue Creek)
Fort Belvoir (Federal)
Pentagon (Federal)

Also contributing to the pollution of the estuary have been combined sewer overflows from the District of Columbia and Alexandria, and raw sewage bypassed in the District of Columbia.

Waste discharges from the District of Columbia and Virginia cause pollution of the interstate waters of the Potomac River which endangers health or welfare of persons living in Maryland, Virginia and the District of Columbia, and therefore is subject to abatement under the provisions of the Federal Water Pollution Control Act.

Pollution discharged to Rock Creek and the Anacostia River in Maryland causes pollution of the interstate waters of Rock Creek and the Anacostia River which endangers the health and/or welfare of persons in the District of Columbia, and therefore is subject to abatement under the provisions of the Federal Water Pollution Control Act.

* The District of Columbia Water Pollution Control Plant receives wastes from 340 square miles of Prince Georges and Montgomery counties in Maryland with a population of 876,000 and 100 square miles in Virginia with a population of 82,000 in addition to the 60 square miles in the District with a population of 810,000.

RECOMMENDATIONS

To meet Federal and State standards and to enhance water quality in the Potomac River estuary in the Washington, D.C. area, it is recommended that:

1. Waste treatment facilities be provided and maintained to ensure compliance with water quality standards. Meeting these standards at *present waste loads and discharge locations* requires a 98 percent reduction in raw sewage fecal coliform densities, and a 96 percent reduction in 5-day 20 degree C. BOD₅, with a maximum total discharge of 16,500 lbs/day BOD₅.

2. Phosphorus reduction facilities be provided for all wastes discharged to the Potomac estuary to prevent excessive algal growths. Meeting this recommendation at *present waste loads and discharge locations* requires a 96 percent reduction in total phosphorus (P) from all sources.

3. An evaluation be made of the feasibility of discharging effluent from the District of Columbia Water Pollution Control Plant through several outlets along the estuary rather than through the existing single outfall. Water quality advantages of multiple outlets should be assessed because these may indicate that reductions are possible in the extremely high removal percentages that are otherwise necessary for specific waste constituents. Before discharge all wastes must receive the highest degree of treatment practical, including phosphorus removal.

As waste loads increase, the degree of treatment provided by all plants must be such that the quality of the receiving waters, including the estuary and the tributaries thereto, is maintained within the requirements of the applicable standards.

4. Completion of the District of Columbia's revised Plan C for the elimination of combined sewer overflows and raw sewage diversion to the Potomac and Anacostia Rivers and Rock Creek be achieved as rapidly as feasible, with especial reference to advancement of the completion date insofar as possible for eliminating raw sewage discharges.

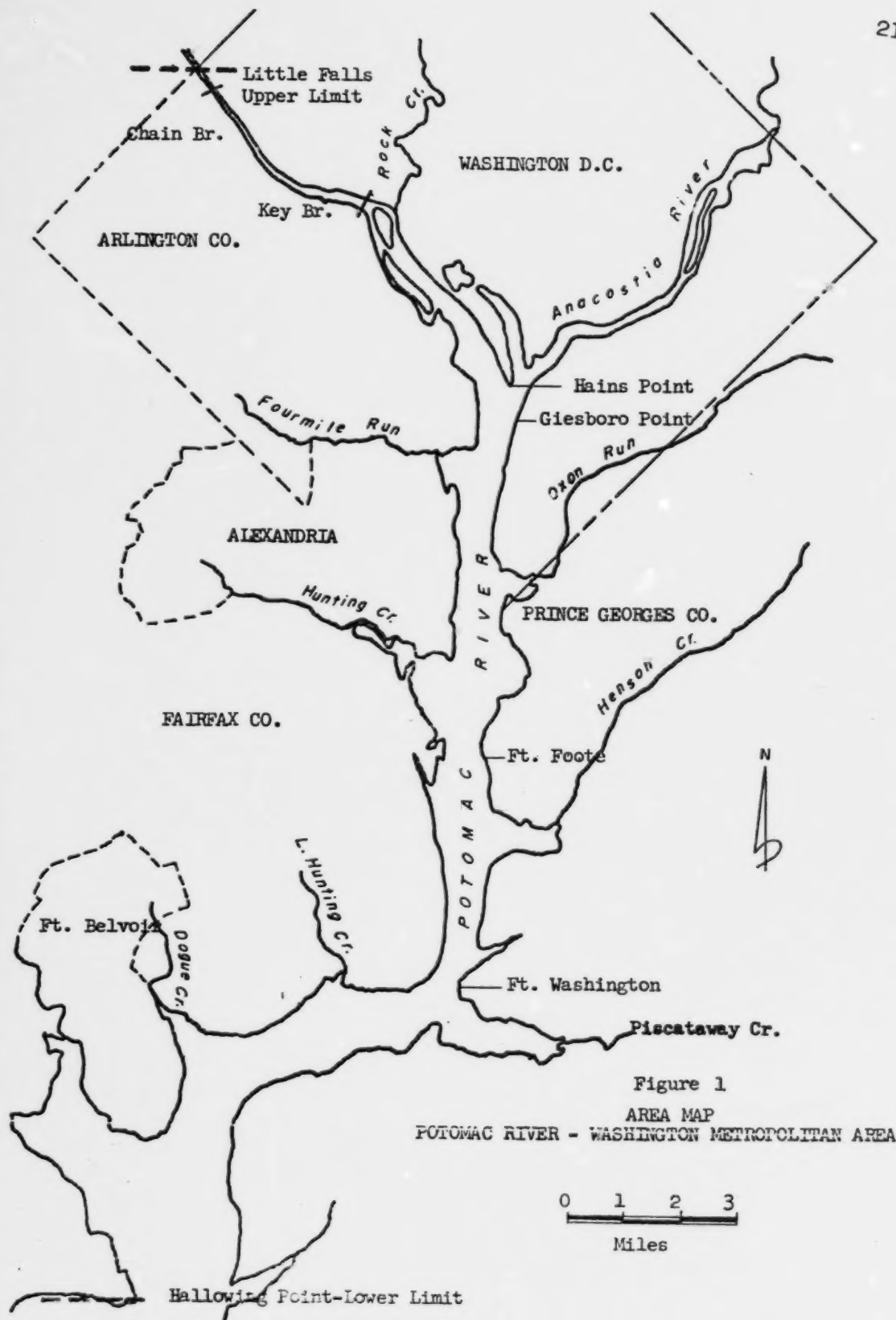
The State of Maryland take action to eliminate the pollution entering Rock Creek and the Anacostia River upstream from the Maryland-District of Columbia line.

Alexandria, Virginia, undertake a program commensurate with that of the District of Columbia for control of raw sewage discharges through combined sewer overflows and diversions.

5. Existing local, municipal, county, state, interstate, and Federal agencies involved in erosion and silt control unite in an expanded, coordinated effort to implement the 10-year accelerated silt control program for the Potomac River Basin including the Anacostia River and Rock Creek that was recommended by the Sedimentation and Erosion Sub-Task Force.

Seneca Dam and Reservoir site be preserved at its present level of economic development in accordance with the recommendation of the Potomac River Basin Advisory Committee and the Federal Interdepartmental Task Force in their "Potomac Interim Report to the President."

6. A systematic program be developed and conducted to prevent the disposal of trash, debris, junk, and other objectionable material adjacent to and into waterways. "Operation Clean Waters," a cooperative effort between the government of the District of Columbia and the Federal Government utilizing enrollees of the Neighborhood Youth Corps, is an example of the type of cooperative program needed.



BACKGROUND

On August 22, 1957 the Surgeon General of the U.S. Public Health Service, Department of Health, Education and Welfare, who at that time was responsible for the Federal Water Pollution Control Program, called a Conference on pollution of interstate waters of the Potomac River in the Washington Metropolitan Area (District of Columbia, Maryland, Virginia) (Figure 1). A second session of the Conference was convened on February 13, 1958.

This initiation of Federal enforcement action was the culmination of nearly a half century of Public Health Service interest in and concern over pollution of the Potomac in the metropolitan area.

The interest started with a comprehensive study of the effects on the river of the raw sewage from 320,000 persons in 1913-1914, and mild concern was expressed, in the conclusions of the subsequent report, that "the capacity of the river to dispose of (raw) sewage without nuisance or danger will eventually be overtaxed" and in the recommendation that "primary treatment works should be installed in the near future" by the District of Columbia for "the example in such matters that should be afforded by the national capital."

As the sewered population increased, mounting concern was reflected in subsequent Public Health Service reports issued at approximately ten-year intervals. In 1925, it was concluded that no section of the river adjacent to the District of Columbia "could be considered free enough from pollution with sewage to permit its use for bathing without a potential danger to such bathers of contracting sewage-borne diseases." Primary treatment or extension of an intercepting sewer downstream was recommended.

In 1932, with raw sewage from 575,000 persons pouring into the Potomac, the resulting pollution was described as critical. Bacterial pollution rendered the river unsuitable for bathing from Three Sisters Island to Fort Washington, a distance of 14 miles. Fish were endangered by reduction of dissolved oxygen concentrations to less than one-half their natural values in the four and one half miles between Giesboro Point and Fort Foote. Primary treatment again was recommended, but it was suggested that the plant design incorporate provisions for subsequent addition of secondary

treatment. Action by the major polluter, the District of Columbia, followed the report, and five years later a primary treatment plant was placed in operation. During the 1930's smaller Maryland and Virginia communities in the Washington Metropolitan Area also completed treatment plants.

The primary treatment plants were designed to remove only about one-third of the oxygen-demanding organic matter. By 1943, when the 1,149,000 sewered population of the metropolitan area was double that of 1932, the Potomac was receiving an organic load that was one-third greater than it had been in 1932, before any treatment was provided. The treated effluents from all treatment plants carried a combined organic load equivalent to that in the raw sewage from 781,000 persons (population equivalent, or P.E.). The 1944 report recommended that secondary treatment be provided.

By the time of the 1957 session of the Conference the sewered P.E. of the metropolitan area had increased to 1,678,000, or 46 percent over that of 1943. There was an equivalent increase in P.E. of the treated sewage to 1,143,000. Thus, the treated sewage in 1957 had a P. E. very nearly twice that in 1932 when there was no treatment. Of this load, 82.8 percent was contributed by the District of Columbia Blue Plains Sewage Treatment Plant, which received the sewage from the Maryland Suburban Sanitary District as well as that from the District. Federal installations with their own sewage treatment plants, the Pentagon and Ft. Belvoir, contributed 1.6 percent of the total load. Three Virginia jurisdictions, Arlington and Fairfax counties and Alexandria, accounted for the remaining 15.6 percent. In addition to the treated sewage the Potomac River received discharges of undetermined quantities of raw sewage, both directly and by way of tributaries such as Rock Creek and Anacostia River, from combined sewers, overloaded interceptors, and pumping station and treatment plant bypasses.

The ever-increasing sewage load inevitably resulted in increasing degradation of water quality in the Potomac. Bacterial contamination that rendered the water hazardous to the health of bathers and others coming in contact with the water extended at least from Three Sisters Island to Hallowing Point, a distance of 22.4 miles.

Sampling and laboratory analysis by District of Columbia treatment plant personnel that provided the data for the 1957 report did not extend beyond Hallowing Point, and it cannot be determined how much farther downstream excessive bacterial densities persisted. Excessive DO depletion, hazardous to fish and other aquatic life, extended from the Twin Highway Bridge at least to Hallowing Point, a distance of 19.0 miles. Obnoxious floating solids from raw sewage overflows or bypasses destroyed the natural beauty of extensive areas of the river's surface. Foul odors emphasized the occurrence of pollution in the vicinity of overflows and bypasses, especially near the Lincoln Memorial and along the Washington Channel and the Anacostia River.

The District of Columbia already had completed plans for extension of its sewage treatment plant at the time of the Conference. The conclusions and recommendations as agreed to by the conferees and included in the Conference Summary issued by the Surgeon General on April 4, 1958 are as follows:

1. That cognizance is taken of the work done by the official water pollution control agencies of the District of Columbia, Maryland, and Virginia and the Interstate Commission on the Potomac River Basin in recognizing, analyzing, and acting to secure abatement of pollution of the interstate waters of the Potomac River - Washington Metropolitan Area;

2. That cognizance is taken of the remedial facilities installed by the District of Columbia, Maryland and Virginia political subdivisions to abate such pollution;

3. That the District of Columbia will provide secondary treatment (including chlorination of the effluent when necessary) at its Blue Plains plant by 1958 that will remove 80 percent of the waste load going through that plant as measured by BOD;

4. That the District of Columbia will make further improvements to the Blue Plains plant which will be completed by 1965. These

improvements will provide full secondary treatment which will result in the continued removal of 80 percent of the wastes going through the plant as measured by BOD;

5. That the District of Columbia make plans sufficiently in advance so that additional construction which may be necessary beyond that contemplated to be completed by 1965 will be accomplished so that discharges from the Blue Plains plant will not again become a significant source of pollution of the Potomac River (Washington Metropolitan Area);

6. That the District of Columbia, in order to reduce pollution of the Potomac River (Washington Metropolitan Area) from storm water overflows, put into effect Plan C (except the Rock Creek interceptor) as proposed by the Board of Engineers in its "Report to District of Columbia Department of Sanitary Engineering on Improvements to Sewage System" dated February 28, 1957; and that the construction of these remedial facilities be completed by the end of 1966; and appropriate financial arrangements be made to accomplish this;

7. That the Virginia communities in the Washington Metropolitan Area will provide treatment commensurate with those provided by the District of Columbia and Maryland political subdivisions;

8. That processes be initiated to define what responsibility the Federal Government should have in the program to abate pollution of the Potomac River in the Washington Metropolitan Area;

9. That the official State water pollution control agencies of the District of Columbia, Maryland, Virginia, and the Interstate Commission on the Potomac River Basin cooperate with each other in the provision and exchange of information on a continuous sampling program of the quality of water of the Potomac (Washington Metropolitan Area); and

10. That the Public Health Service will report to the other conferees as to progress at six-month intervals.

CURRENT STATUS

WATER USES

Water uses are essentially the same as they were in 1957, but there have been increases in numbers of those using the Potomac as the metropolitan population has increased.

The water supply intakes for the Washington Metropolitan Area are some distance upstream from Little Falls, the upper limit of the Potomac considered in this report. The water is returned as treated and untreated sewage, to be carried away by the river.

Throughout the 26-mile reach under consideration (Figure 1), from Little Falls to Hallowing Point, recreation is a major use of the river. Pleasure boating is predominant, and water skiing, swimming and fishing are popular pastimes. Many of the area's beautiful parks border the Potomac and Anacostia rivers and Rock Creek. Thousands of residents and both national and international visitors enjoy the scenic beauty of these waters daily in the parks, from other vantage points, and in passing.

Navigation is an important use of the Potomac River and the lower Anacostia. Those engaged in navigation, its attendant activity, channel maintenance and other work on the streams come into both direct and indirect contact with the waters.

The principal industrial use of the Potomac River water is for cooling processes.

WATER SOURCES

Sewage treatment plant effluents are the principal wastes that affect the quality of Potomac River water. The river and tributary streams, including Rock Creek and Anacostia River, intermittently receive variable waste discharges, including sewage from combined sewers, overloaded interceptors and bypasses, and washings from storm water runoff.

Treated Sewage

Operating records of the sewage treatment plants in the area were furnished by the various sewer departments, and provide the basis for the following discussion. Nine plants in the area treat sewage with an oxygen demand P.E. of 2,456,000 (Table 1 and Figure 2), a 46.4 percent increase

since 1957. The treated sewage has a combined P.E. of 673,900 for a reduction since 1957 of 41.0 percent in the organic load discharged to the river by the treatment plants. This P.E. is 17.2 percent greater than it was in 1932 before any treatment was provided.

Figure 3 shows the increase in sewered population from 1913 to 1967, together with the corresponding P.E. of the treated sewage. The first downward trend in the organic load discharged to the Potomac since this series of reports on Potomac River pollution started is attributable principally to improved treatment by the District of Columbia Water Pollution Control Plant (formerly the District of Columbia Blue Plains Sewage Treatment Plant).

In addition to receiving sewage from the District, the District of Columbia Water Pollution Control Plant accepts sewage from the Washington Suburban Sanitary Commission, several governmental bodies in Virginia, and several Federal agencies. This is done under agreements between the District and the agencies concerned. Payment to the District of Columbia is based on the cost of construction and maintenance of sewers and the cost of treating the sewage contributed. The WSSC operates the plant located on Piscataway Creek. The Federal Government operates treatment plants at the Pentagon and Fort Belvoir. Three jurisdictions in Virginia operate five plants. Alexandria and Arlington County are responsible for one each, and Fairfax County for three, the Westgate, Little Hunting Creek and Dogue Creek plants. The Fairfax County sewage formerly treated in its Pimmit Run plant is now conveyed across the river into the District of Columbia sewerage system. The points of effluent discharge and the relative organic loads in the various discharges are shown in Table 1 and Figure 4. The District of Columbia plant contributed 75.8 percent of the total load. The five Virginia plants accounted for 22.5 percent, the WSSC Piscataway plant for 1.1 percent, and the two Federal plants for 1.0 percent.

Table 2 includes data on suspended solids in the raw and treated sewage of the nine treatment plants. The combined suspended solids load of 531,400 pounds per day was reduced 73.8 percent to 138,900 pounds per day. In a year's time the Potomac received more than 25,000 tons

Table 1
SOURCES OF SEWAGE DISCHARGED TO THE POTOMAC RIVER
IN THE WASHINGTON, D. C. METROPOLITAN AREA
Oxygen Demand

Source	Discharge Location	BOD, lbs/day (1) (5 day, 20° C)		Population (2) Equivalent		Percent of total sewage load to the Potomac River		
		Influent	Effluent % Removed	Influent	Effluent	Influent P.E.	Effluent P.E.	
Alexandria, Va.	Hunting Creek	40,000	9,500	76.2	222,220	52,780	9.1	7.8
Arlington Co., Va.	Fourmile Run	36,000	3,600	90.0	200,000	20,000	8.1	3.0
Fairfax Co., Va								
Westgate	Hunting Creek	25,100	12,600	49.8	139,440	70,000		
Little Hunting Creek	Little Hunting Creek	5,100	1,000	80.4	28,330	5,560		
Dogue Creek	Dogue Creek	3,100	600	80.6	17,220	3,330		
Total Fairfax Co.		33,300	14,200		184,990	78,890	7.5	11.7
District of Columbia	Potomac River	320,000	92,000	71.2	1,777,800	511,100	72.4	75.8
Pentagon	Boundary Channel	1,440	240	83.3	8,000	1,330	0.3	0.2
Ft. Belvoir	Dogue Creek	2,910 ⁽³⁾	470 ⁽³⁾	84.0	16,170	2,610	0.7	0.4
Washington Suburban Sanitary District – Piscataway Plant	Piscataway Creek	8,500	1,300	84.7	47,220	7,220	1.9	1.1
Total		442,150	121,310	72.6	2,456,400	673,930	100.0	100.0

Notes:

(1) Based on Plant Records--most current available

(2) Based on 0.18 lb. BOD per capita for comparison with 1957 report

(3) Estimated

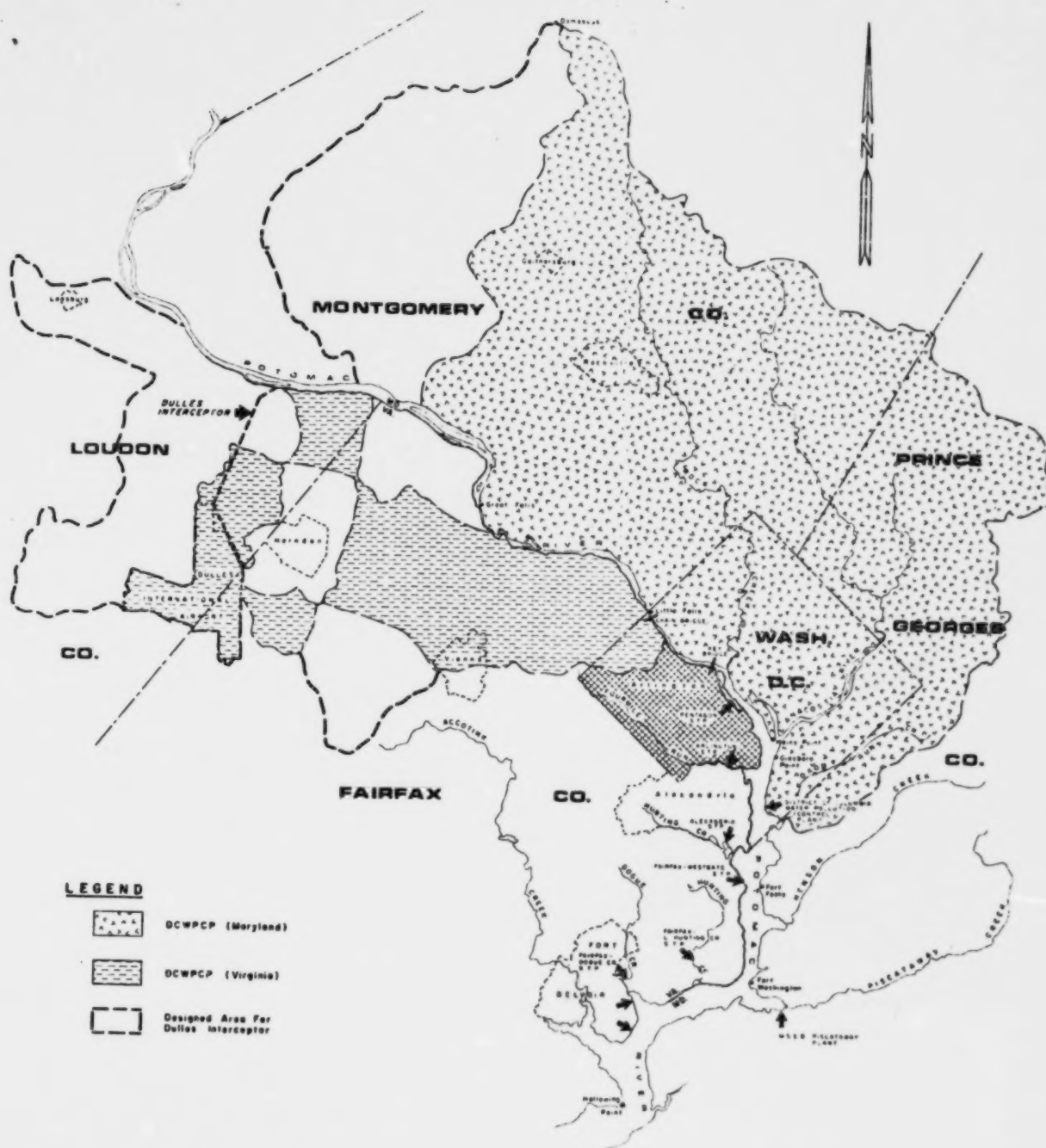
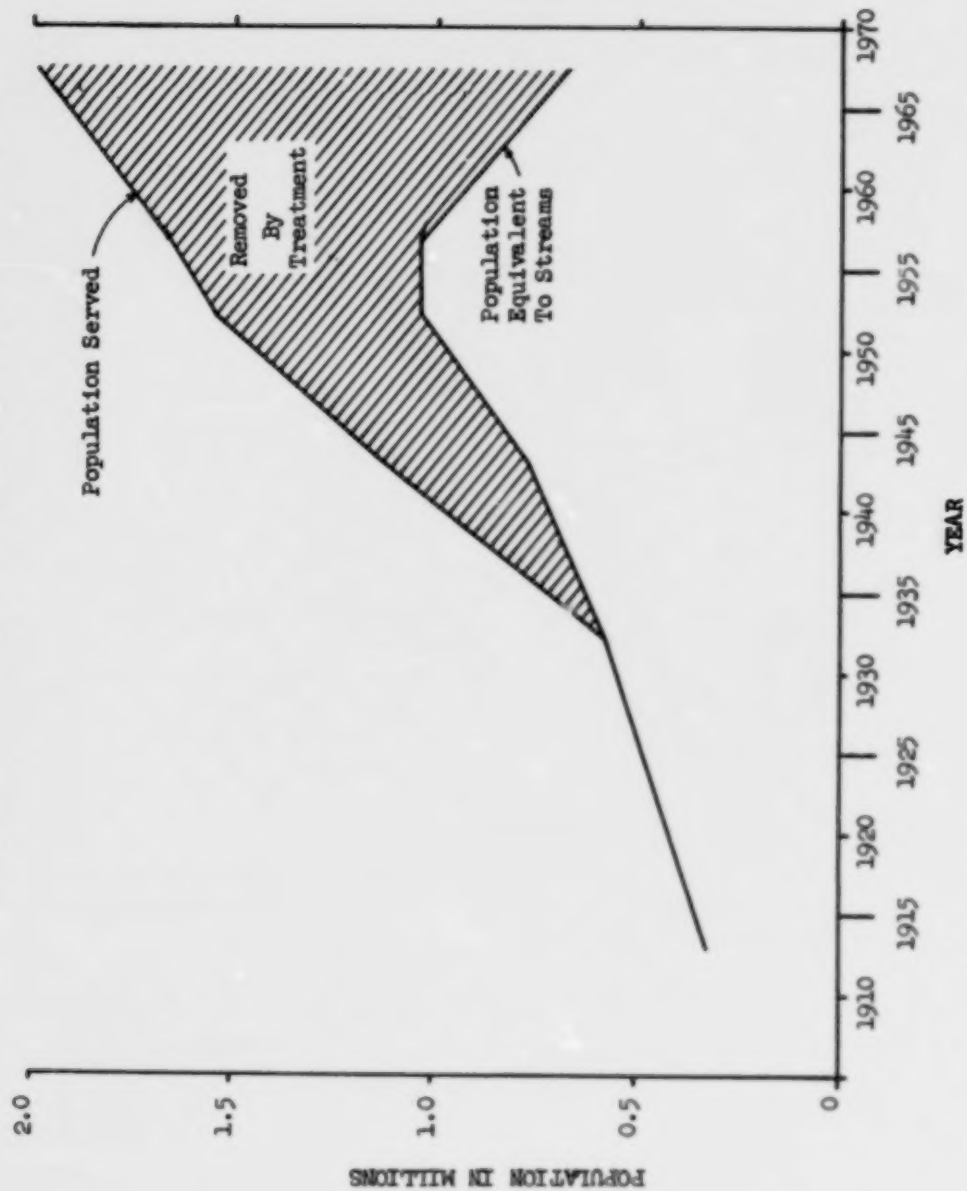


FIGURE 2

MAJOR WASTE SOURCES
POTOMAC RIVER - WASHINGTON METROPOLITAN AREA

Figure 3
POTOMAC RIVER WASHINGTON METROPOLITAN AREA
TRENDS IN POPULATIONS CONTRIBUTING SEWAGE TO RECEIVING WATERS



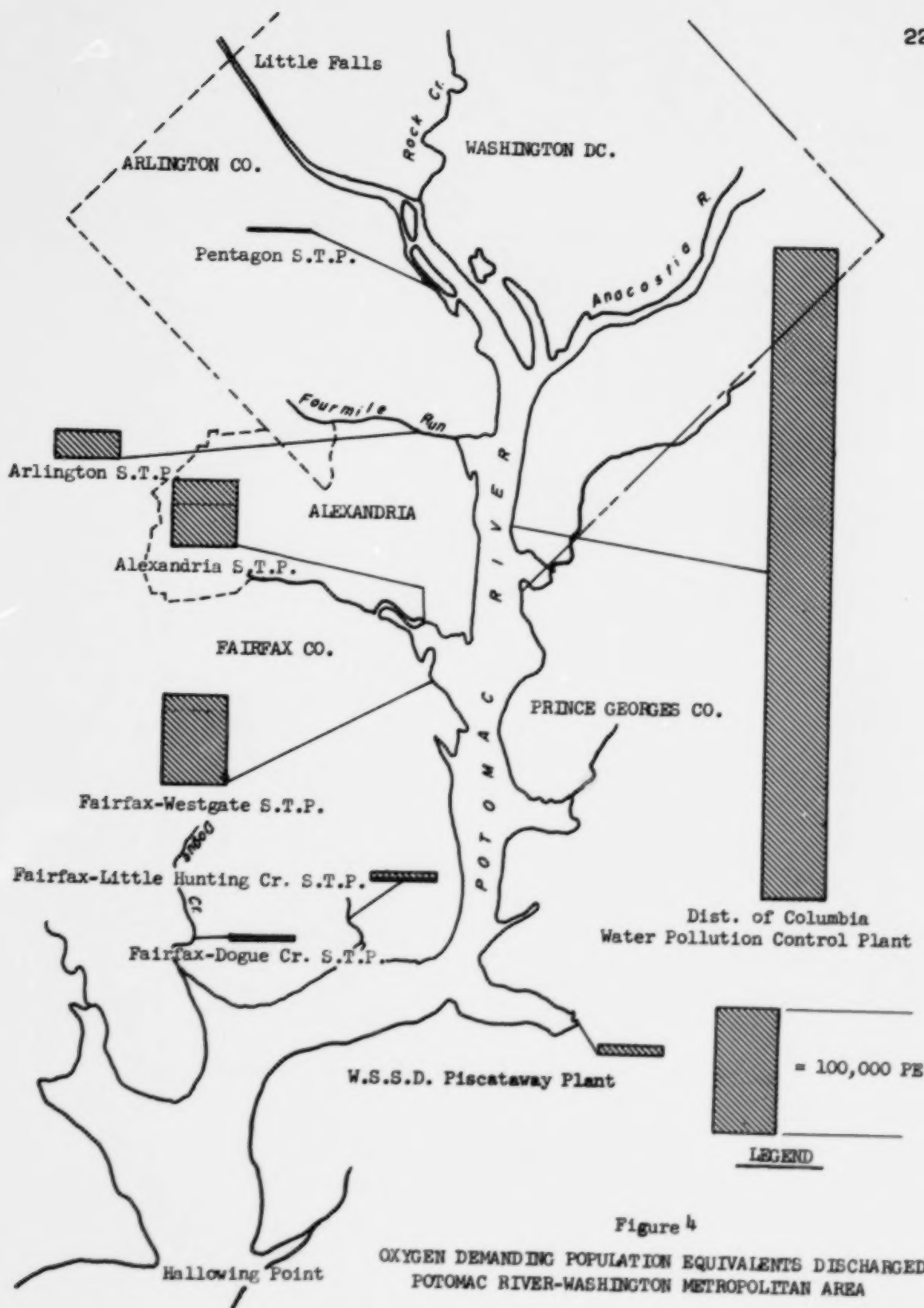


Table 2

SOURCES OF SEWAGE DISCHARGED TO THE POTOMAC RIVER
IN THE WASHINGTON, D. C. METROPOLITAN AREA
Suspended Solids

Source	Discharge Location	Suspended Solids(1)		Population(2)		Percent of total sewage load to the Potomac River		
		Influent	Effluent	% Removed	Influent	Effluent	Influent P.E.	Effluent P.E.
Alexandria, Va.	Hunting Creek	36,000	9,600	73.3	180,000	48,000	6.7	6.9
Arlington Co., Va.	Fourmile Run	44,000	3,800	91.4	220,000	19,000	8.3	2.7
Fairfax Co., Va. Plants								
Westgate	Hunting Creek	22,000	10,000	54.5	110,000	50,000		
Little Hunting Creek	Little Hunting Creek	4,200	900	78.6	21,000	4,500		
Dogue Creek	Dogue Creek	2,400	700	70.8	12,000	3,500		
Total Fairfax Co.		28,600	11,600		143,000	58,000	5.4	8.4
District of Columbia		408,000	112,000	72.5	2,040,000	560,000	76.8	80.6
Pentagon	Boundary Channel	1,600	340	78.8	8,000	1,700	0.3	0.2
Ft. Belvoir	Dogue Creek	3,200(3)	485(3)	85.0	16,170	2,430	0.6	0.4
Washington Suburban Sanitary District – Piscataway Plant	Piscataway Creek	10,000	1,100	89.0	50,000	5,500	1.9	0.8
Totals		531,400	138,925	73.8	2,657,170	694,630	100.0	100.0

Notes:

- (1) Based on Plant Records—most current available
 (2) Based on 0.2 lb suspended solids per capita per day
 (3) Estimated

of suspended solids in the combined plant effluents. Of this, 80.6 percent was from the District of Columbia plant, 18.0 percent was from the five Virginia plants, 0.8 percent from the WSSC plant, and 0.6 percent was from the Pentagon and Fort Belvoir plants.

Raw sewage contains tremendous numbers of bacteria and other organisms, some of which are pathogenic. Even after conventional treatment, unless the effluent is disinfected, hazardous quantities of pathogenic organisms may be discharged from sewage treatment plants. Although data are not available either on reductions of bacteria by existing treatment or on numbers in the effluents of the Washington Metropolitan Area plants, bacteriological data on the river reveal that control of bacteria was

inadequate to prevent serious hazards to the health of those who came in contact with the water.

Phosphorus is an essential nutrient for the growth of aquatic plants. In the reach of the Potomac considered, excessive aquatic plant growth is one of the adverse effects of pollution. Data on the quantities of phosphorus in the sewage can be estimated on the basis of sewered populations. The total phosphorus (as P) in waste sources prior to treatment was estimated to be 21,100 pounds per day. Reductions are less than 20 percent by the sewage treatment plants currently utilized in the metropolitan area. Data on phosphorus in the Potomac River show that there was far more than the minimum necessary to support excessive aquatic plant growths.

Status of Compliance with Conferees' Recommendations

The District of Columbia plant reduced the raw sewage BOD 71.2 percent (Table 1) compared to the 25 percent reduction accomplished in 1957. This was a worthwhile improvement, but was still

less than the 80 percent reduction recommended by the conferees in February 1958.

Plants that accomplished improved percentage reductions since 1957 are:

Source	1957 Effluent Loads		Current Effluent Loads	
	P.E. Discharged	% Removal Efficiency	P.E. Discharged	% Removal Efficiency
District of Columbia	946,020	25.0	511,100	71.2
Alexandria, Va.	38,610	64.0	52,780	76.2
Fairfax Co., Va. Little Hunting Cr.	2,540	35.0	5,560	80.4
Dogue Creek	1,460	35.0	3,330	80.6
Fort Belvoir, Va.	16,000 ⁽¹⁾	30.0 ⁽¹⁾	2,610 ⁽¹⁾	84.0 ⁽¹⁾
Arlington Co., Va.	103,070	42.2	20,000	90.0 ⁽¹⁾

⁽¹⁾Estimated

Two plants failed to equal the reductions of 1957:

Source	1957 Effluent Loads		Current Effluent Loads	
	P.E. Discharged	% Removal Efficiency	P.E. Discharged	% Removal Efficiency
Pentagon	1,820	89.5	1,330	83.3
Fairfax Co.—Westgate	32,140	55.9	70,000	49.8

The WSSC Piscataway plant was not in operation in 1957.

The organic load to the river increased from four of the eight plants that were in operation in 1957 and at present. The Arlington County, District of Columbia, Pentagon and Fort Belvoir plants had reductions in their organic effluent loads when compared to 1957.

Six of the nine plants accomplished the 80 percent reduction recommended for the District of Columbia by the conferees. The Alexandria and District plants approached compliance with the recommendations at 76.2 and 71.2 percent, respectively. The Westgate plant of Fairfax County (48.9 percent) failed to provide treatment "commensurate with those provided by the District of Columbia and Maryland political subdivisions" (71.2 percent) as recommended by the conferees for the Virginia plants. If all plants had accomplished the recommended 80 percent reduction, the combined P.E. of all effluents would have been 491,000, or 73 percent of the 673,900 P.E. being discharged. The combined reduction by all plants was 72.6 percent compared to 32 percent in 1957, a commendable improvement though short of the required reduction.

The conferees also recommended chlorination of effluents "when necessary." The bacterial densities of the Potomac, reported subsequently, clearly demonstrated the immediate necessity of chlorination of sewage effluents for protection against hazards of waterborne diseases of all who come in contact with the water in the river. The stream data clearly demonstrate, also, that effective disinfection of effluents was not being practiced.

Raw Sewage

Raw sewage was discharged to the streams of the area in several different ways. Sewage pumping stations and treatment plants normally are equipped with bypasses to prevent hydraulic overloading or flooding of these facilities following rainfall and increased sewage flows. Sewage interceptors are equipped with overflow devices that operate when peak flows exceed their hydraulic capacities. Combined sewers, carrying both sewage and storm water, are provided with overflow devices that operate during and following rain storms when the combined flow exceeds the design capacity. Such diversions to the streams are for the prevention of the hydraulic overloading of the sewerage facilities. Portions of the sewer systems of the District of Columbia and Alexandria consist of combined sewers.

The total quantity of raw sewage that reached the streams of the area from all sources is not known, but a report for the District of Columbia by its Board of Consultants provided estimates of combined sewer overflows for the District's system. Estimates of overflows from overloaded interceptors were made by District of Columbia personnel. Since the District sewage comprised nearly three-quarters of this area's total, these estimates covered a major portion of the area's total raw sewage discharge.

The estimated annual discharge of raw sewage from the District system to the Potomac and Anacostia Rivers and Rock Creek was 5,222 billion gallons per year (Table 3) in 1960 when a program to reduce such discharges was initiated. About 4 billion gallons per year, or 11 million gallons per day (mgd), of this was continuous dry weather

flow from the Anacostia and Rock Creek main interceptors. The estimated P.E. of this discharge was 74,000. The remaining 1.222 billion gallons per year, or about one fourth of the total, was intermittent combined sewage overflow to the three streams. Although this averaged 3.3 mgd for the year, actually there were days, during dry weather, when there was little or no overflow and others, during and following rains, when the discharge rate was many times this average.

In the absence of a more direct estimate of combined sewer overflow from Alexandria, it may be assumed that the discharge from that community would be in proportion to that of the District of Columbia, adjusted for the relative populations served by the respective combined sewer systems. On this basis the Alexandria overflow would have been about 86 million gallons per year, or an average of 0.24 mgd, for an estimated P.E. of 2,100.

Rock Creek, flowing through beautiful Rock Creek Park, received intermittent overflows of raw sewage from the overloaded Rock Creek Main Interceptor and from combined sewers following rains. It also received raw sewage from defective or broken sewers and surface runoff from both rural and urban areas. Wastes reached the creek from the National Zoological Park. Two hundred and eleven separate sewer outlets had been identified as potential conveyors of sewage or surface runoff to the creek.

The Anacostia River received overflows from combined sewers, as well as surface runoff and wastes from several industries.

Status of Compliance with Conferees' Recommendations

The District of Columbia is conducting a commendable program designed to collect raw sewage discharges for treatment (Table 3). Since the program started in 1960 nearly 40 percent of the raw sewage discharges have been eliminated. Most of this (2 billion gallons per year) was overflow of Washington Suburban Sanitary District sewage to the Anacostia River from the overloaded Anacostia River Main Interceptor at Blaine Street. The remainder was combined sewer overflow, eliminated by closure of 14 overflow points.

Construction currently underway and scheduled for completion in 1969 will eliminate overflow from the Rock Creek Main Interceptor and other combined sewer overflows. This will

reduce the raw sewage discharge by another two billion gallons per year, a 78 percent reduction since 1960. Plans have been made to provide treatment of the wastes from the Zoological Park presently discharging to Rock Creek.

The remaining 22 percent of the 1960 raw overflow is principally from combined sewers. A program of sewer separation is underway, but must be carried out at a pace that will not cause either excessive financial burden or unreasonable disruption of traffic, and is not planned for completion before the year 2000. In the meantime, there is a continuing program of separating combined building plumbing. Separate system sewers and sewer relief projects in general are being constructed in advance of scheduled highway, street paving and urban renewal programs. These preliminary measures will facilitate future sewer separation by reducing traffic disruption and avoiding costly highway and street excavation.

The present 300 mgd peak capacity of the District of Columbia Water Pollution Control Plant will be increased to 528 mgd to meet needs until 1980. Sedimentation and chlorination facilities will be provided for partial treatment of an additional 289 mgd during periods of stormwater runoff. When completed, 40 percent of the combined system flow received at the plant during storms will be given complete treatment and 60 percent will receive partial treatment.

Industrial Wastes

Government is essentially the only "industry" in the Washington Metropolitan Area. Industries that are so essential to the economy of other cities of this size are practically nonexistent. The few significant industries known to discharge directly to streams of the area included those listed in Table 4.

Rock Creek received water softener backwash, boiler blowdown and cooling water from the District of Columbia West Heating Plant, and small quantities of oil from two establishments.

The Anacostia River received cooling water from two electric generating plants and washwater from two sand and gravel plants.

Silt

Erosion occurs throughout the Potomac River Basin (Figure 5 and Table 5), and silt eroded from the farthest point in the watershed ultimately can

Table 3

POTOMAC RIVER

Untreated Sanitary Sewage Overflows to Potomac River

(From separate and combined sewers)

	Sanitary Sewage Overflow Mg/Yr	Percent of Total
A. Sanitary Sewage Overflows to be Eliminated (1969) ¹		
Amount included in "1957 Report" data	1,330	25.4
Anacostia Main (incl. Maryland connection)	2,000	38.3
Additional Rock Creek Main Interceptor (RCMI) ²	<u>1,892</u>	<u>36.3</u>
Total Requiring Elimination	5,222	100.0
B. Overflows Eliminated by Modified Plan "C" Construction from 1960 to 1966		
1963 Anacostia Closure	2,000	38.3
1960-1966 Plan "C" Construction ³ (178 closures minus 108 rerouting)	<u>70</u>	<u>1.3</u>
Amount Eliminated, 1966	2,070	39.6
(Amount Remaining to be Eliminated)	(3,152)	(60.4)
C. Overflow Elimination Expected by 1969		
Completion of 2-story Sewer	2,000	38.3
Previous 1960-1966 Eliminations	<u>2,070</u>	<u>39.6</u>
Expected Elimination by 1969	4,070	77.9
(Remaining Amount to be Eliminated from 1969-2000)	(1,152)	(22.1)

1. Including flows from Maryland to Anacostia connection and from the 1958-1962 increased flow to the Rock Creek Main Interceptor.
2. The RCMI 108 portion of the 2,000 mgd total was included in the "57 Report" data (2,000-108=1,892)
3. Total closures effected 178 mgd; but 108 of this from RCMI enters the partially completed 2-story sewer for temporary by-pass downstream (178 - 108 = 70).

Table 4
 SOURCES OF INDUSTRIAL WASTE
 Potomac, Anacostia and Rock Creek

Location	Industry	Waste Type
Potomac River		
Rock Creek		
	H. & D. Metro Ford Tractor Co.	Tractor cleaning
	D. C. West Heating Plant	Cooling water, boiler & softener blowdown
Anacostia River		
	Mineral Pigments Corp.	Pigments, chrome
	A. H. Smith Sand & Gravel Co.	Sand & gravel wash
	U. S. Naval Ordnance Laboratory	Cooling water
	Wm. H. McCeney Co.	Sand & gravel wash
	Lustine Chevrolet Co.	Engine cleaning
	PEPCO Benning Generating Station	Cooling water
	Potomac Sand & Gravel Co.	Sand & gravel wash
	PEPCO Buzzard Point Generating Station	Cooling water
PEPCO Generating Station		Cooling water
Naval Research Laboratory		Cooling water & radioactive waste

Data Source

Municipal and Industrial Waste Inventory -- Potomac River Basin.
 Prepared by Chesapeake Field Station -- October 1966.

ESTIMATED AVERAGE ANNUAL SEDIMENT YIELDS
AT SELECTED POINTS ON THE POTOMAC RIVER
(Based on U. S. G. S. Estimates)

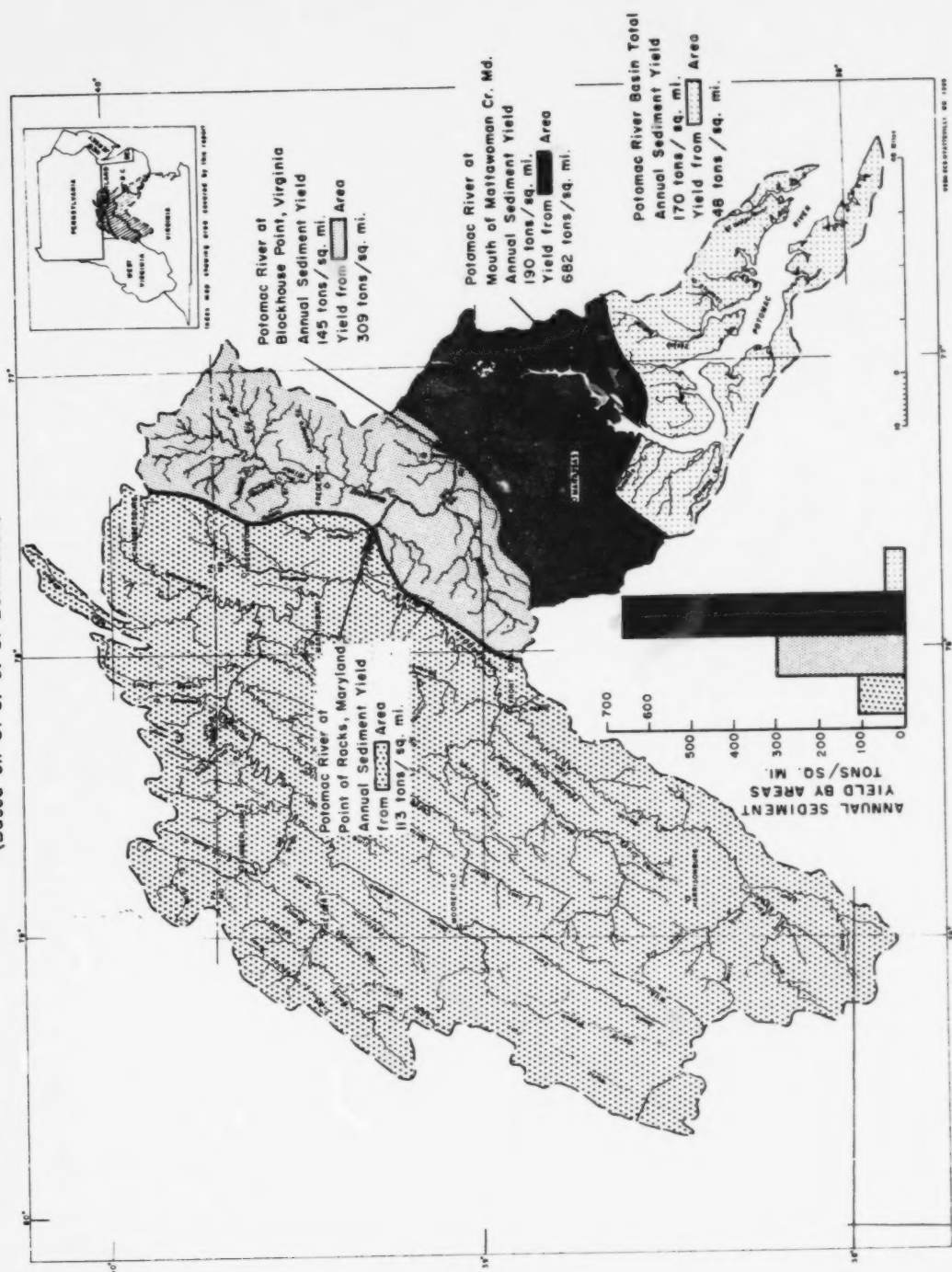


Table 5

Estimated Average Annual Sediment Yields

Location	Area		Yield Tons/sq.mi. per Yr.	Average Yield	
	Sq. Mi.	% of Total		Tons/Yr.	% of Total
Basin upstream from Point of Rocks, Maryland	9,651	66	113	1,090,000	44
Point of Rocks, Maryland, to Blockhouse Point, Maryland	1,880	13	309	580,000	23
Blockhouse Point, Maryland, to Mattawoman Creek, Maryland. (Includes area covered by this report)	1,070	7	682	730,000	29
Mattawoman Creek, Maryland, to mouth at Chesapeake Bay	2,070	14	48	100,000	4
TOTAL	14,670	100.0	170	2,500,000	100

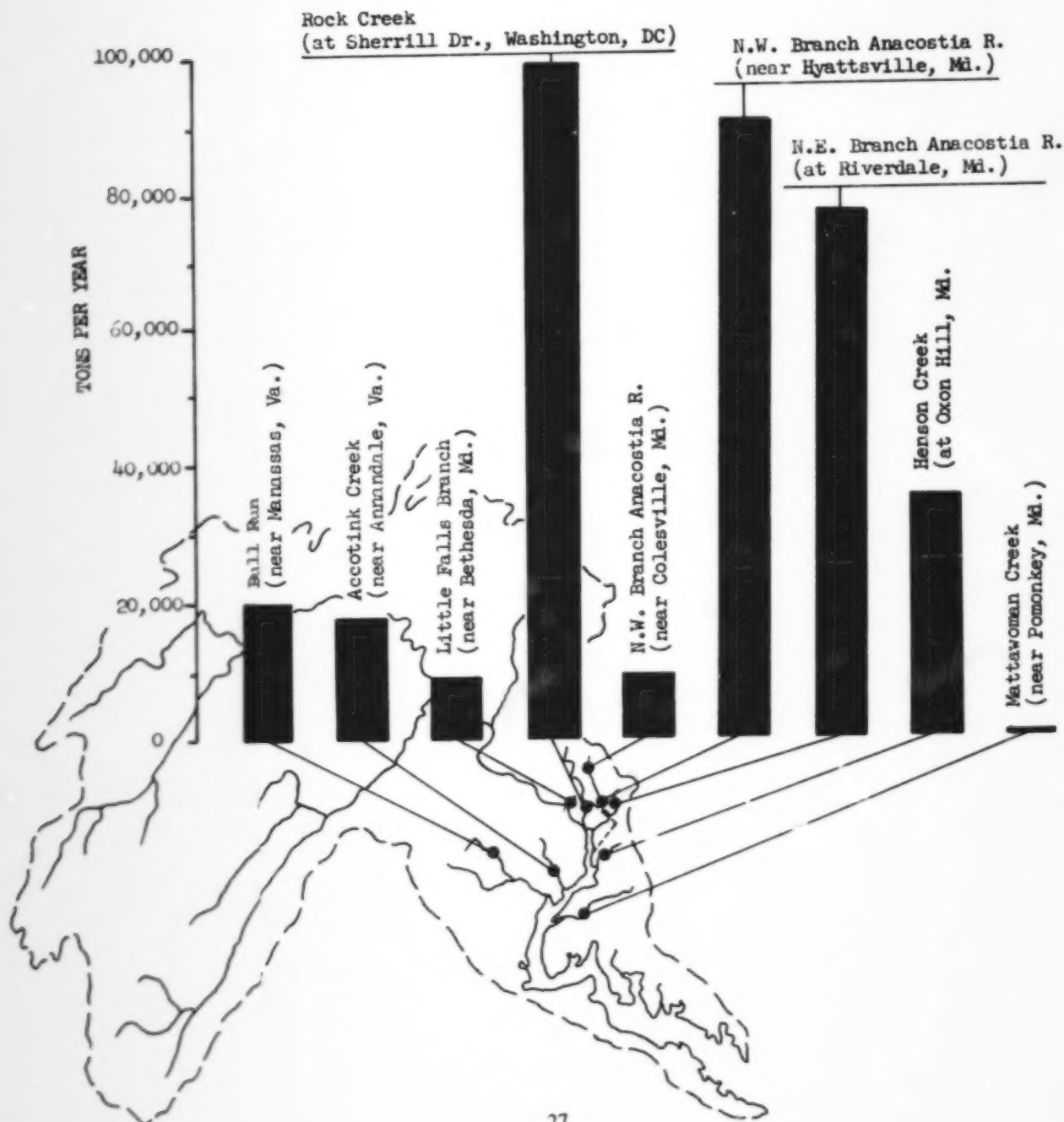
Table 6

Computed Average Annual Discharge of Silt
in Streams in the
POTOMAC RIVER BASIN

STATION	Drainage Area (sq.mi.)	Average Annual Sediment Discharge	
		Tons	Tons per sq. mile
Little Falls Branch (near Bethesda, Md.)	4.1	9,530	2,320
Rock Creek (at Sherrill Drive, Washington, DC)	62.2	99,500	1,600
N.E. Branch Anacostia R. (at Riverdale, Md.)	72.8	77,400	1,060
N.W. Branch Anacostia R. (near Colesville, Md.)	21.3	10,000	470
N.W. Branch Anacostia R. (near Hyattsville, Md.)	47.4	91,300	1,850
Henson Creek (at Oxon Hill, Md.)	16.7	36,000	1,850
Accotink Creek (near Annandale, Va.)	23.6	17,800	690
Bull Run (near Manassas, Va.)	147.0	21,400	146
Mattawoman Creek (near Pomomkey, Md.)	57.7	1,830	32

Figure 6

COMPUTED AVERAGE ANNUAL DISCHARGE OF SILT IN STREAMS
IN THE POTOMAC RIVER WASHINGTON METROPOLITAN AREA



contribute to turbidity of the Potomac River in the metropolitan area, and to deposits on the bottom of the river. The magnitude of the problem of controlling so many sources of silt distributed over such a large area is obvious.

Soil erosion and the quantity of silt that results are greatly influenced by the type of land use. Silt losses vary from as little as 20 tons per square mile per year for forested lands and those with undisturbed vegetative cover to as much as 50,000 tons per square mile per year for construction areas undergoing urban development. It is obvious that erosion is greatest in the most populous areas.

Data on silt contributed to the Potomac from the metropolitan area alone are not available, but 730,000 tons per year were contributed from the area tributary to the river between Blockhouse Point, Virginia, and the mouth of Mattawoman Creek, Maryland. This area comprises only seven percent of the basin's area and includes the metropolitan area. By contrast, the contribution from the 78 percent of the basin above Blockhouse Point was only a little over twice that from the Blockhouse Point-Mouth of Mattawoman Creek area, or 1,670,000 tons per year.

More specific sources of silt, but minor contributors in relation to the total, included strip

mines for coal, ceramic clay and glass sands in the upper basin and sand and gravel washing operations in the upper estuary area.

Annual silt loads carried by tributaries of the Potomac River in the general metropolitan area are given in Table 6, and are shown in Figure 6. Two tributaries in the District of Columbia, Rock Creek, with 100,000 tons per year, and the Anacostia River with 169,000 tons per year, contributed nearly 37 percent of the total silt discharge to the Potomac in this area and nearly 11 percent of that in the entire basin. The area drained by the two tributaries represents only about 1.25 percent of the total Potomac Basin.

Stormwater Runoff

Most of the silt reaching the streams is carried there by runoff following rainfall. The runoff, especially from urban areas, contains other constituents that may cause pollution. These include oxygen-demanding organic matter, bacteria, and phosphates among other constituents.

No special studies of the loads of pollutants in surface runoff have been made in the Washington Metropolitan Area.

EFFECTS OF WASTES ON WATER QUALITY AND USES

In spite of the reductions in wastes that have been accomplished since 1957, there has been only minor improvement in the severely polluted condition of the Potomac River.

Data on water quality of the Potomac River have been obtained regularly by personnel of the District of Columbia Water Pollution Control Plant since the plant was placed in operation in 1937. Recent data have been made available for use in this report as they were for the 1957 report.

WATER QUALITY STANDARDS

Under the provisions of Section 10(c)(3) of the Federal Water Pollution Control Act (of 1965), the District of Columbia and the States in the Potomac Watershed, Pennsylvania, Maryland, West Virginia and Virginia, submitted standards for interstate streams to the Secretary of the Interior. Since the State boundary for Virginia follows the near shoreline of the Potomac, Virginia has not set standards for the main stem of the Potomac but has prepared standards for the tributary and estuarine waters in the tidal portions which are within its boundary. The Secretary of the Interior has approved standards for Maryland and, with some exceptions, those of West Virginia, Pennsylvania and the District of Columbia. Standards submitted by Virginia are currently under review.

Water Quality Standards are comprised of criteria to protect specified water uses and plans to attain or maintain these criteria, prevent unwarranted degradation of existing high quality streams, and enhance the quality of degraded streams to allow more beneficial uses. These criteria also provide a basis for evaluating the individual or accumulative effects of various polluting materials.

Each of the standards contain general criteria applicable to all waters and are substantially in accordance with the following:

The water shall not contain substances attributable to municipal, industrial, or other waste discharges in concentrations or amounts sufficient to be inimical or harmful for water uses or to human animal, plant or aquatic life. Specific substances to be controlled include, but are not limited to, debris, oil, scum, and other floating materials; toxic substances; substances that produce color, tastes, odors, or settle to form

sludge deposits.

In addition to the General Criteria, specific criteria to protect water have been adopted for designated zones of the interstate coastal waters. The water quality standards in table form for the interstate waters of the Potomac River are presented in Table I of the Appendix. The code used in Table I to identify the criteria adopted for a specific zone is explained in Table II.

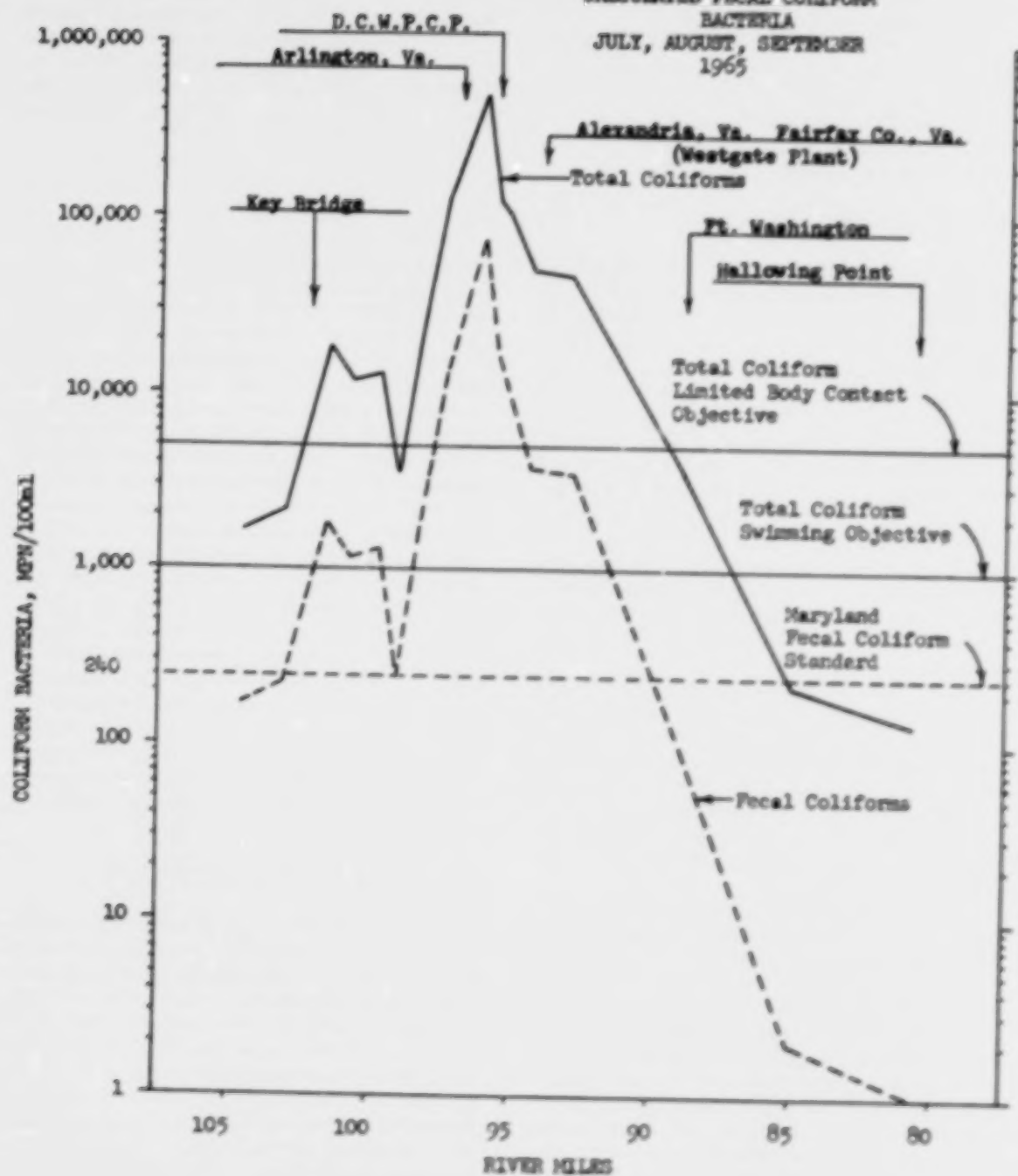
The Secretary of the Interior has stated that a basic policy of the Act is to protect and enhance the quality of the Nation's waters and has concluded that implementation of this policy requires substantially the following:

"Waters whose existing quality is better than the established standards as of the date on which such standards become effective will be maintained at their existing high quality. These and other waters of the District will not be lowered in quality unless and until it has been affirmatively demonstrated to the District of Columbia water pollution control agency and the Department of the Interior that such change is justifiable as a result of necessary economic or social development and will not interfere with or become injurious to any assigned uses made of, or presently possible in, such water. This will require that any industrial, public or private project or development which would constitute a new source of pollution or an increased source of pollution to high quality waters will be required, as part of the initial project design, to provide the highest and best degree of waste treatment available under existing technology, and, since these are also Federal standards, these waste treatment requirements will be developed cooperatively."

BACTERIAL POLLUTION

The 1957 report presented bacteriological data that were cited as being "...a picture of extreme bacterial contamination which renders the river hazardous to the health of those who use it for any type of recreation that involves contact with the water." It was stated also that "At no point can it be considered safe for swimming." There has been only moderate improvement in bacterial control through sewage treatment since then, and the conclusions of that and of earlier reports regarding the grave hazards to health of using the

Figure 7
 POTOMAC RIVER ESTUARY
 OBSERVED TOTAL COLIFORM
 BACTERIA
 AND
 CALCULATED FECAL COLIFORM
 BACTERIA
 JULY, AUGUST, SEPTEMBER
 1965



river for recreation still apply. Data on coliform bacteria provided by the staff of the District of Columbia Water Pollution Control Plant serve as the basis for this conclusion.

Figure 7 and Table III-Appendix show the average most probable numbers (MPN) of coliform bacteria for the Potomac River for the months of July, August and September, 1965, which was a low stream flow period (846 cfs). Limits of coliform bacteria commonly used are 1,000 per 100 ml (a little less than one-half cup of water) for swimming and other whole-body contact sports and 5,000 per 100 ml for limited-body contact sports, such as boating and fishing. On this basis, the river was unsuitable for any type of recreation from Key Bridge downstream almost to Fort Washington, a distance of about 13 miles. It would be unsuitable for swimming from Fletcher's Boat House, above Three Sisters Island, to one mile below Fort Washington, a distance of more than 16 miles.

The maximum three-month average coliform density observed in 1965 was 521,000 per 100 ml just above the District of Columbia sewage plant. This was more than 100 times the partial-body contact limit and over 500 times the body contact limit. It was equal to more than 300 coliform bacteria per drop of water.

The bacterial standard for the Maryland portion of the Potomac River is not based on total coliform, but on the more recently developed method for fecal coliform bacteria. These bacteria are essentially all of fecal origin and therefore are much more specific for fecal pollution than are total coliforms.

No fecal coliform data were available for the reach of the Potomac River under consideration. However, it is possible to estimate the probable fecal coliform densities within reasonable limits on the basis of fecal coliform data obtained on other streams.

Calculated fecal coliform densities are incorporated in Figure 7 with the observed total coliform data discussed above. The calculated peak value of 78,000 fecal coliforms per 100 ml just above the District's plant outfall is more than 300 times the Maryland limit of 240 per 100 ml for recreation. The estimated densities exceed this limit from about Key Bridge to Fort Washington, a distance of a little more than 13 miles.

Data obtained by the total coliform method show that sewage discharged in the Washington Metropolitan Area causes a serious hazard to health of all who use the Potomac for any type of

recreation. This conclusion is strongly supported by estimated densities of fecal coliform bacteria, which are the basis for the approved Maryland water quality standards.

A limited quantity of fecal coliform data is available on Rock Creek in Maryland (Table 7). Seven of 10 sampling stations yielded fecal coliform densities in excess of the Maryland standard of 240 per 100 ml. The greatest average density of 2,570, or about 10 times the standard, occurred at the station nearest the District of Columbia line. No fecal coliform data were available on Rock Creek in the District, but data on total coliforms at five stations have been accumulated over a period of years (Table 8). Since 1963 the monthly average total coliform density has exceeded 5,000 per 100 ml at all stations every month of the warm weather period, July through September. More than half the monthly averages exceeded 25,000 per 100 ml, and several exceeded 100,000 per 100 ml.

In both Maryland and the District of Columbia, water-contact uses of Rock Creek involved a distinct hazard to health.

Bacterial data on the Anacostia River were available for only the District of Columbia reach of the river (Table 9). Averages for July through September have been quite erratic at the seven sampling stations within the District. In 1963 average total coliforms at five of the seven stations approached or exceeded one-half million per 100 ml, indicating the probable discharge of raw sewage to the river. In 1964 and 1965 densities were much lower, with no monthly average exceeding 100,000 per 100 ml, though densities generally were greater than 5,000 per 100 ml. In 1966 densities increased, with averages at three of the seven stations exceeding one-half million. The lowest density always had occurred at the station nearest the mouth of the river, indicating that the bacterial pollution came from upstream rather than from the Potomac River through tidal action.

Contact with the water of the Anacostia River within the District of Columbia was hazardous to health.

OXYGEN DEMAND

Sewage and many industrial wastes contain organic matter that decomposes in water and in so doing exerts a demand on the dissolved oxygen of the receiving stream. If the oxygen demand is great enough and the ability of the stream to

Table 7

Bacteriological Analyses of Rock Creek Grab Samples - June and August 1966

Miles from Potomac River Confluence	Sample Location	Number of Samples	Coliforms (MPN/100ml)	Fecal Coliforms (MPN/100ml)	Fecal Streptococci (MPN/100ml)
> 23.8	Needwood Road	1	1,300	330	93
> 23.8	Muncaster Road	2	3,350	1,850	1,140
23.8	Avery Road	2	1,100	110	250
23.1	Norbeck Road	1	460	210	130
21.2	Viers Mill Road	2	1,020	315	150
17.3	Knowles Avenue	1	2,400	1,300	330
14.8	Cedar Lane	7	26,500(a)	1,740	1,980
14.6	NNMC - Bethesda	1	2,400	61	20
13.5	Kensington Avenue	1	9,200	260	110
11.3	Coquelin Run				
11.1	East-West Highway	5	58,400(a)	2,570	8,190

(a) One result reported as > 160,900. For arithmetic average, the density was taken as 160,900.

Table 8

Summary of Average Monthly Coliform Densities for the D.C. Reach of Rock Creek

Year		Coliform Density (MPN/100 ml)				D.C. Line (9.1)
		Pennsylvania Avenue (0.6)	Park Road (3.9)	Military Road (7.6)	Sherrill Drive (8.6)	
1962	July	-	-	-	-	-
	August	-	-	-	-	-
	September	-	-	-	-	-
1963	July	105,000	32,000	30,400	71,000	8,350
	August	107,000	40,000	15,500	47,000	100,000
	September	33,200	32,000	20,600	51,500	4,640
1964	July	55,000	38,000	35,000	13,000	36,000
	August	23,000	14,500	12,000	25,000	10,600
	September	18,000	20,000	7,800	13,000	33,000
1965	July	94,000	25,000	37,000	48,000	24,000
	August	121,000	92,000	76,000	100,500	60,000
	September	41,600	37,000	39,000	40,000	40,000
1966	July	594,000	12,650	27,200	45,577	45,580
	August	39,320	17,780	9,505	16,380	24,220
	September	31,170	15,170	35,530	161,770	9,600

NOTE: With the exception of 1963, the coliform densities are arithmetic averages. The 1963 densities are geometric mean values.

The number in parentheses under each sampling station is the miles from the confluence with the Potomac River.

Table 9

Summary of Average Coliform Densities for the Anacostia River

Year ^(a)	Total Coliforms (MPN/100 ml)					
	Washington Channel (1.1)	South Capitol Street (2.0)	11th Street Bridge (2.8)	Pennsylvania Avenue (3.6)	East Capitol Street (4.8)	Bennin ₂ Street (5.3)
1962	6,050	51,300	82,500	122,000	943,000	124,000
1963	24,200	477,000	430,000	948,000	3,510,000	458,000
1964	3,760	9,180	17,900	21,800	6,060	37,200
1965	2,580	4,680	94,600	30,100	34,800	27,400
1966	9,030	111,000	578,000	163,000	42,900	555,000
						D.C. Line (7.2)
						121,000
						27,700
						41,400
						21,400
						608,000

34

(a) Arithmetic average for samples collected during July, August, and September.

NOTE: For each sampling station, the number in parentheses refers to the miles from the confluence with the Potomac River.

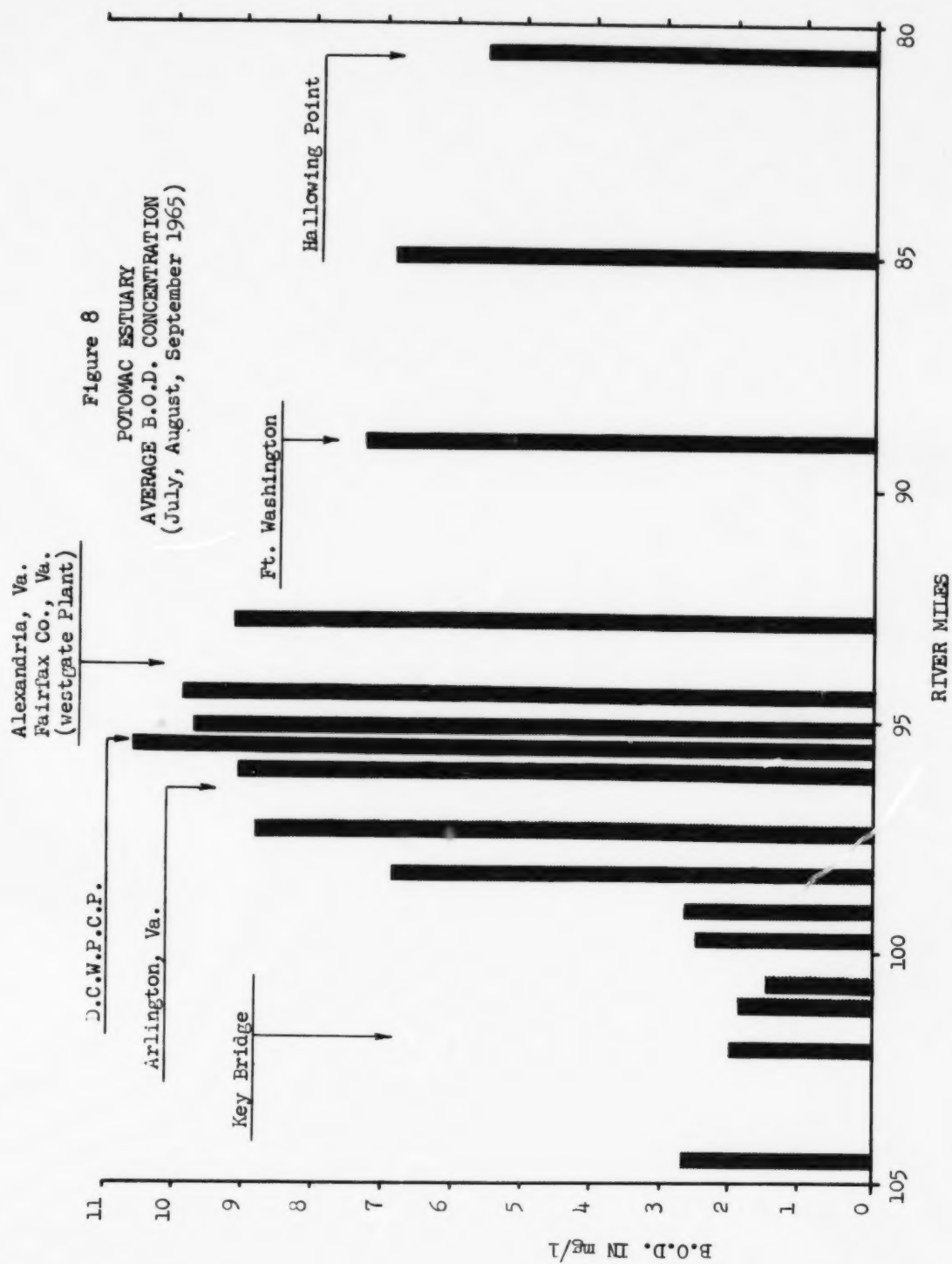


Table 10

Summary of Average Monthly 5-day BOD's for the D.C. Reach of Rock Creek

5-day BOD (20°C) - (mg/l)

Year	Pennsylvania Avenue	Park Road	Military Road	Sherrill Drive	D.C. Line
1962					
July	2.6	0.7	2.4	2.9	3.1
August	1.7	2.0	1.7	1.8	2.2
September	-	-	-	-	-
1963					
July	3.3	3.2	3.7	3.3	1.2
August	1.8	3.1	2.4	2.4	2.1
September	0.9	2.1	1.3	2.6	1.4
1964					
July	2.7	3.5	3.2	4.3	3.7
August	2.0	1.8	1.7	1.9	2.3
September	2.3	2.4	1.4	1.8	2.0
1965					
July	3.7	2.1	2.5	2.9	3.4
August	9.2	7.2	10.3	8.7	6.2
September	4.7	3.9	3.9	4.7	3.6
1966					
July	5.7	1.6	1.1	1.3	1.0
August	6.0	3.1	2.6	3.5	5.6
September	2.3	3.5	1.6	2.0	2.0

recover oxygen from the atmosphere is limited, the essential dissolved oxygen may be reduced to levels that will not support fish and other aquatic life. In extreme cases, if the dissolved oxygen is totally exhausted, the stream gives off the offensive odors of decomposition.

Some, or all, of the organic matter that causes oxygen demand may be carried in the water, but some of the insoluble material may settle to the bottom of the stream, where it forms sludge deposits and continues to exert an oxygen demand.

The oxygen demand of organic matter is exerted over a period of many days, and in the Potomac River estuary where tidal action retains the wastes for a long time, it is necessary to consider the ultimate oxygen demand including that caused by nitrogen compounds. Although measurement of the demand in the laboratory is usually limited to 5 days, it is possible by use of appropriate factors to determine the ultimate demand. The standard 5-day value is known as the 5 day biochemical oxygen demand, or BOD₅.

Biochemical Oxygen Demand

Average BOD₅ values of the water of the Potomac River for the low stream flow months of July through September, 1965 are shown in Figure 8 and Table III-Appendix. The 2.7 mg/l of BOD₅ at the farthest upstream sampling point, Fletchers Boat House, was higher than is usual for an unpolluted stream and probably reflected residual organic pollution from upstream wastes.

The BOD₅ dropped to 1.5 mg/l at Arlington Memorial Bridge, and then started to climb as the tidal action of the Potomac carried sewage upstream from the point of discharge of the District of Columbia Water Pollution Control Plant effluent. The BOD₅ reached 10.6 mg/l opposite the D.C. plant and then dropped to 5.6 mg/l at Hallowing Point, the farthest downstream sampling station. This value was relatively high for an estuary.

Average monthly BOD₅ values for Rock Creek within the District of Columbia for the months of July through September, 1962 through 1966, are shown in Table 10. The monthly values were variable and did not exhibit any consistent pattern. A few values were relatively high (10.6 mg/l maximum) probably reflecting the effects of intermittent storm water runoff or overflow from a sewer. In general, the monthly averages were not excessive for a shallow, swift stream of

this type

The BOD₅ data for Anacostia River within the District in Table 11 are similar to those for Rock Creek. They exhibited no definite pattern and although the single maximum BOD₅ (7.8 mg/l) was not so high as the maximum for Rock Creek, on the whole the values for the Anacostia tended to be higher than those for Rock Creek.

The Anacostia River within the District is much deeper and slower than Rock Creek, and therefore has a much lower reaeration capacity. The BOD₅ values for the Anacostia could seriously deplete the DO of this stream.

Bottom Oxygen Demand

In addition to the BOD₅ of the river water, independent measurements were made of oxygen demand of sludge deposits. The results are shown in Figure 9. About 1 gram of oxygen demand per square meter per day is normal for an unpolluted estuary. The maximum measured values were nearly three times this in the vicinity of and below the D.C. Water Pollution Control Plant. The sludge oxygen demand was 2 grams per square meter per day or greater, indicative of gross pollution for a distance of 10 miles, from East Potomac Park to 0.5 mile above Riverview, Maryland. The effluent from four major sewage treatment plants of the metropolitan area discharges in this reach, and suspended solids from these plants contributed to the sludge deposits that caused the high oxygen demand.

DISSOLVED OXYGEN

Average and minimum dissolved oxygen (DO) values for July through September 1965 are shown in Figure 10 and are tabulated in Table III-Appendix. The river entered the estuary with an average DO of 7.4 mg/l. The average DO dropped below 5 mg/l about three miles above the D.C. plant and fell as low as 2.8 mg/l opposite the plant. It remained below 5 mg/l to Fort Washington for a total distance of about eleven miles.

The minimum DO for the same period was 6.0 mg/l at Fletchers Boat House, dropped below 4 mg/l about 6 miles above the D.C. plant and continued down to a very low 0.4 mg/l opposite the plant. The minimum at the D.C. - Maryland line was about 1.1 mg/l, and did not rise above 4.0 mg/l until about three miles upstream from Hallowing Point. Only coarse and pollution

Table 11

Summary of Average 5-day BOD Concentrations for the Anacostia River

Year ^(a)	5-day BOD (20°C) - (mg/l)					
	Washington Channel	South Capitol Street	11th Street Bridge	Pennsylvania Avenue	East Capitol Street	Benning Street
1962	3.0	3.8	4.0	4.0	5.5	5.2
1963	5.3	6.6	5.3	6.2	7.8	6.7
1964	3.4	4.8	3.9	3.9	2.4	2.9
1965	6.6	5.3	6.2	5.5	4.7	4.4
1966	5.5	6.1	4.7	4.1	6.4	4.4
						5.2
						5.7
						5.0
						4.4
						3.5
						5.2

D.C. Line

Benning Street

East Capitol Street

Pennsylvania Avenue

11th Street Bridge

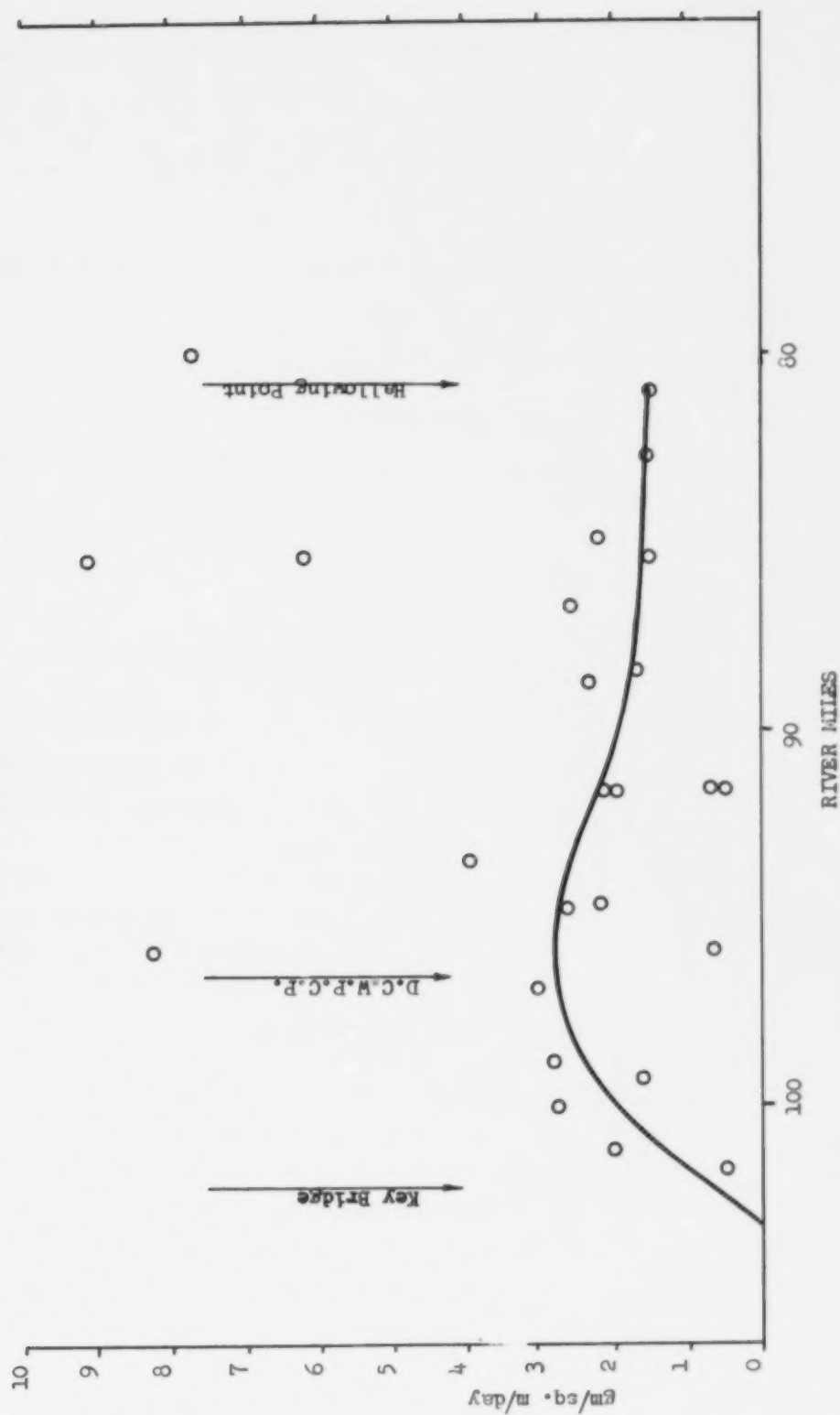
South Capitol Street

Washington Channel

Year^(a)

(a) Arithmetic average for samples collected during July, August, and September.

Figure 9
 POTOMAC RIVER ESTUARY
 BENTHAL UPTAKE vs. RIVER MILES
 BENTHAL LOAD AT 25°C.
 TEMP. CORRECTION - 6%/°C.
 (Measured by Chesapeake Field Station)



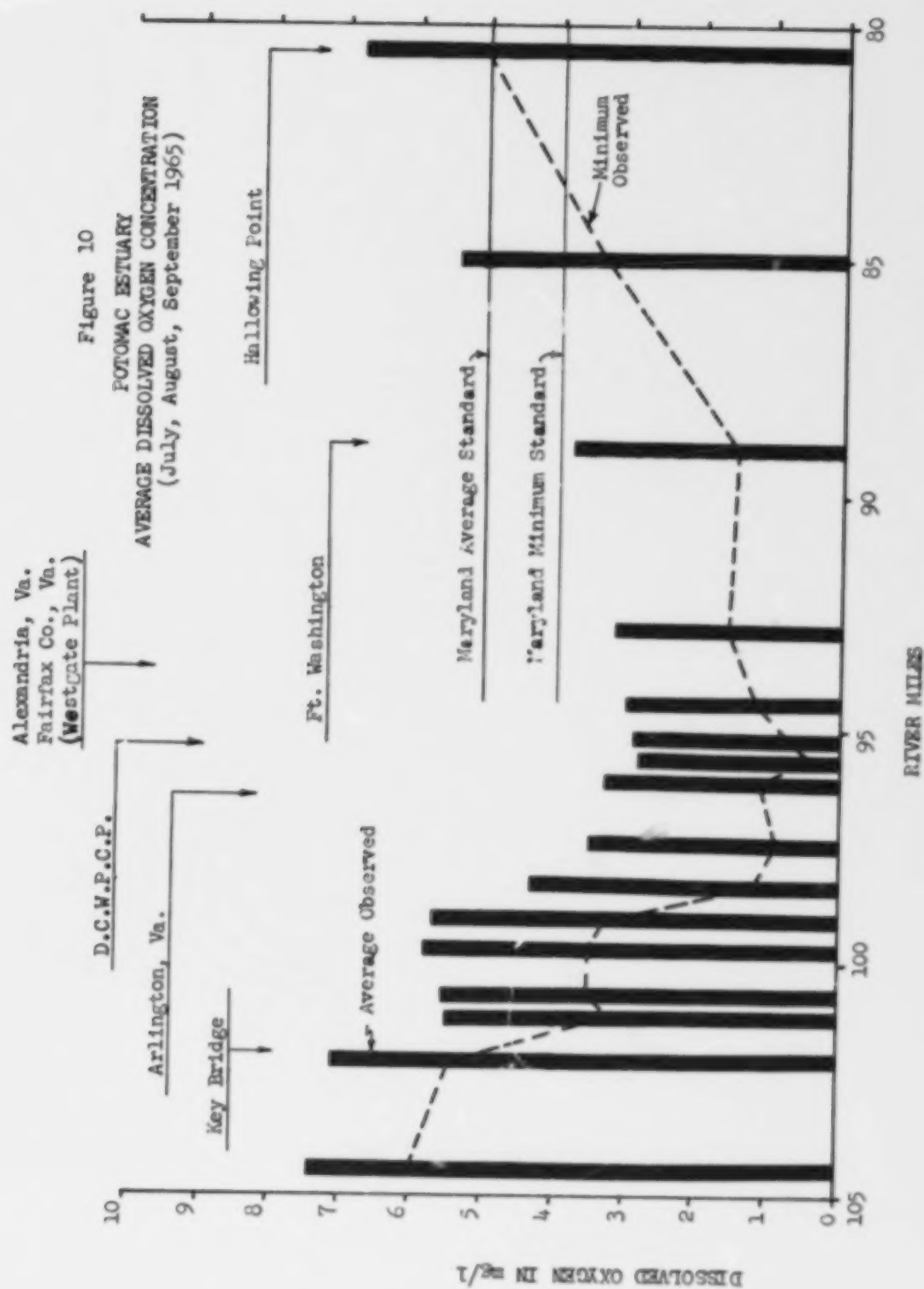


Table 12

Summary of Average Monthly Dissolved Oxygen Concentrations for the D.C. Reach of Rock Creek

Year	Dissolved Oxygen (mg/l)				
	Pennsylvania Avenue	Park Road	Military Road	Sherrill Drive	D.C. Line
1962					
July	7.6	8.4	7.5	8.2	7.6
August	8.4	8.8	9.0	7.8	6.8
September	8.0	8.8	7.9	8.7	7.6
1963					
July	8.5	8.8	9.4	7.9	9.2
August	7.3	9.1	8.3	7.8	7.8
September	8.5	9.1	8.8	7.9	8.3
1964					
July	7.5	8.6	8.1	7.7	7.5
August	8.4	9.4	9.1	8.3	8.2
September	7.6	9.4	9.0	7.8	7.9
1965					
July	7.8	7.8	8.6	8.8	7.8
August	6.9	7.9	6.3	5.9	5.5
September	8.3	9.4	8.6	8.1	7.4
1966					
July	6.5	8.9	8.7	7.9	7.3
August	7.6	9.6	8.7	7.9	7.6
September	8.2	9.3	8.1	7.7	8.1

Table 13

Summary of Average Dissolved Oxygen Concentrations for the Anacostia River

Year(a)	Dissolved Oxygen (mg/l)						D.C. Line
	Washington Channel	South Capitol Street	11th Street Bridge	Pennsylvania Avenue	East Capitol Street	Benning Street	
1962							
Minimum	2.1	1.2	1.4	1.3	1.1	1.1	1.5
Average	5.0	3.0	2.9	2.9	3.1	3.8	4.3
1963							
Minimum	3.6	0.9	0.9	0.5	1.8	0.6	1.7
Average	5.6	3.6	2.7	2.9	3.1	3.4	4.0
1964							
Minimum	5.2	3.7	3.2	2.7	2.4	2.3	2.9
Average	5.9	4.3	4.6	3.3	7.4	3.3	4.2
1965							
Minimum	2.9	2.7	1.4	1.4	2.5	3.0	2.6
Average	6.5	4.4	3.1	3.0	3.2	3.9	3.5
1966							
Minimum	2.8	1.4	2.4	2.3	3.7	3.3	2.0
Average	5.5	3.1	4.4	4.1	5.5	5.6	4.6

(a) The minimum concentration refers to one specific sample. The arithmetic average refers to all the samples collected during July, August, and September.

resistant fish, such as carp and catfish, can be expected in waters with DO as low as this, and even they would not survive in the vicinity of the D.C. plant effluent where DO approached zero.

The average DO levels in Rock Creek for July through September 1962 through 1966 are presented in Table 12. They indicate no excessive oxygen depletion with only two values below 6.0 mg/l and with a minimum of 5.5 mg/l.

Both average and minimum DO levels of the Anacostia River (Table 13) have been low over the years, with minimum values below 1 mg/l at several stations in 1963. There was a trend toward improvement through 1966, but even in that year DO depletion still was excessive, with averages below 5 mg/l and minimum values below 4.0 mg/l at all stations, in the vicinity of 2.0 mg/l at several, and as low as 1.4 mg/l at one.

This reach of the Anacostia River would not support a desirable fish population.

ALGAE

Algae are aquatic plants that range from simple microscopic forms to masses of green and blue-green filaments that may become so abundant that they constitute a nuisance. The microscopic forms can color the water green and may form obnoxious floating scums. They may cause tastes and odors in water supplies and problems of operation in water treatment plants. Changes in water characteristics may cause great numbers of algae to die. They decompose; this decomposition imposes a demand on the DO in the stream which, in addition to the DO used by decomposing man-associated organic pollution may cause serious oxygen depletion, fish deaths and offensive odors. Filamentous algae may line the shore of beaches with slimy masses that make bathing unpleasant or even disagreeable. They can interfere with fishing by collecting in masses on fish hooks, bait and lines. They may wash up on the shore and die to decompose and produce offensive odors.

In waters remote from human influence, phosphorus exists in very low concentrations, principally as a result of solution from the soil. Seasonal changes in aquatic plant and animal production result in cyclic utilization and release of phosphorus to the water. Land runoff carries phosphates from the soil. The discharge of domestic sewage increases the concentration of phosphorus. Phosphorus in the sewage including phosphates from synthetic detergents are the

principal contributions. The additional phosphorus may result in concentrations in the receiving water that are above the minimum requirements for nuisance plant growths.

As nutrient concentrations increase, the numbers of algal cells usually increase. Although some phosphorus is essential to support aquatic life, an upper limit of 0.1 mg/l of total phosphorus (as P) appears to limit algal growths in the Potomac estuary. Concentrations exceeding this level have resulted in nuisance algal blooms.

Another essential nutrient is nitrogen. Nitrogen comes into solution in water as the result of nitrogen fixation by bacteria and blue-green algae from the air, ammonia from rain-out, organic nitrogen from decomposing plants and animals, and from land drainage. The discharge of human wastes results in additional nitrogen. Because of the availability of nitrogen from the atmosphere, it is less amenable to control than phosphorus. More than a total of 0.3 mg/l (as N) of ammonia, nitrate and nitrite nitrogen along with adequate phosphorus will support an abundance of algal growths.

One of the products of algal growth is chlorophyll, the compound that causes the green color of algae and is essential in the photosynthetic reaction that results in the liberation of oxygen from the carbon dioxide used by plants in their growth. Measurement of chlorophyll in water provides one index of the abundance of algae in a stream. When algae are excessive, chlorophyll has been found generally to exceed 50 micrograms per liter ($\mu\text{g/l}$).

Determinations of phosphorus, nitrogen and chlorophyll were made in the Potomac River estuary during 1965 and 1966.

Phosphorus

Average annual total phosphorus concentration in the Potomac at Great Falls during 1966 was 0.109 mg/l.

In January through June 1966 total phosphorus (P) in the Potomac near Woodrow Wilson Bridge, downstream from the D.C. Water Pollution Control Plant averaged 0.522 mg/l, and during an unusually low flow period (300 cfs) in early September the phosphorus ranged from 1.18 to 1.99 mg/l.

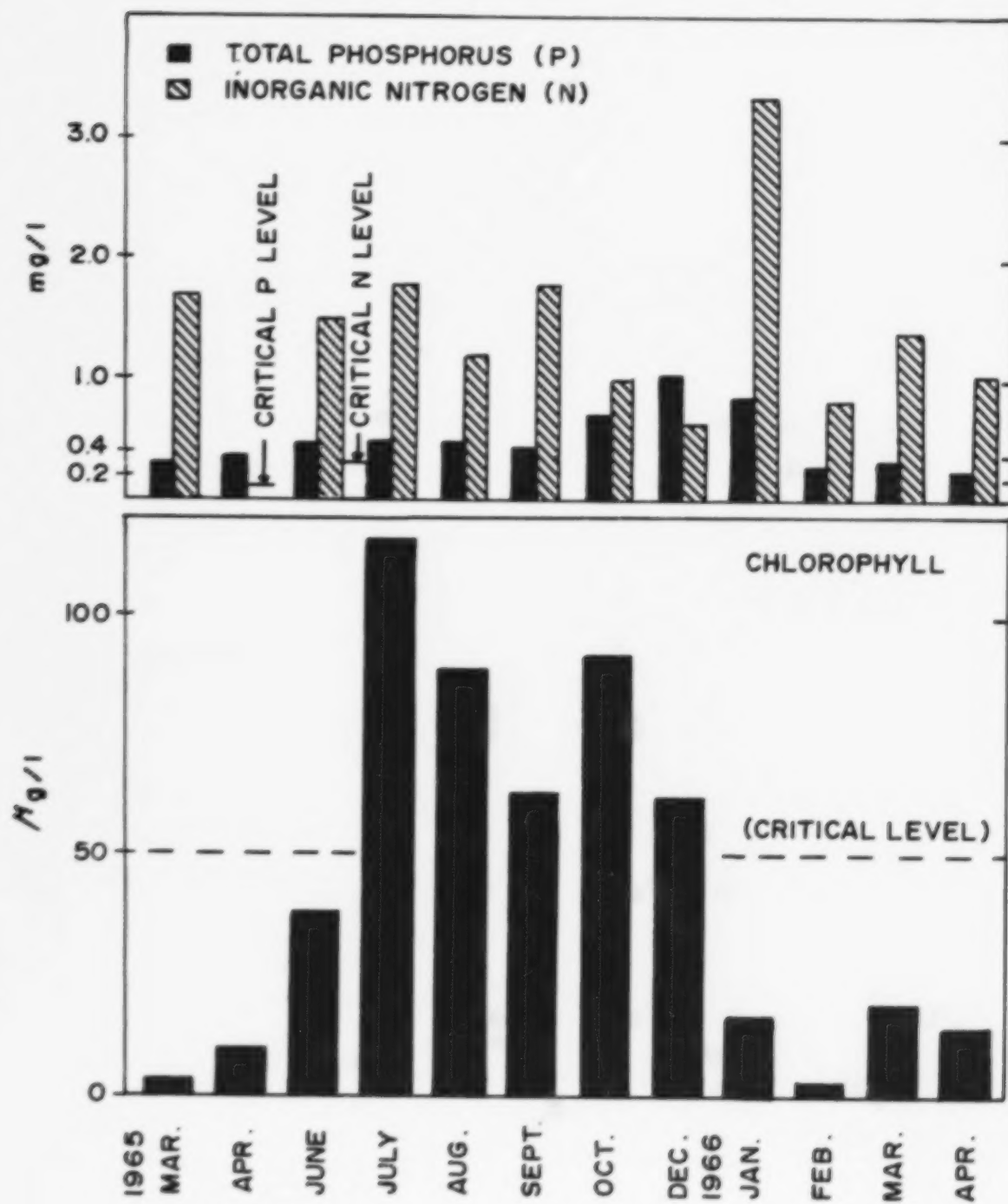
Phosphorus was measured at approximately monthly intervals in the vicinity of Fort Washington (mile 88) from March 1965 through April 1966 (Table 14 and Figure 11). Total

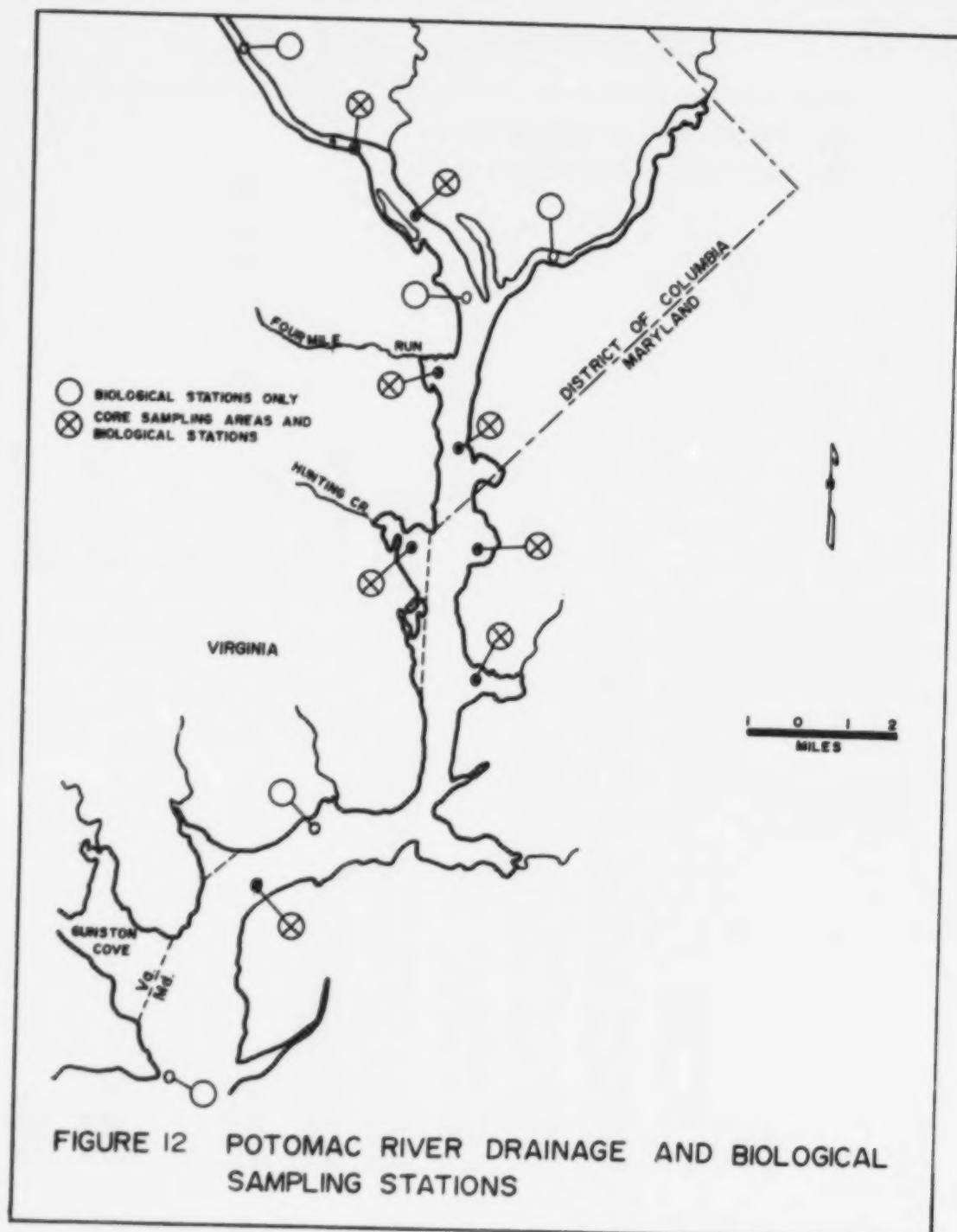
Table 14
Potomac River Nutrient and Chlorophyll Data, Mile 88*

Date	Chlorophyll µg/l	Total Phosphorus P mg/l	Inorganic Phosphorus P mg/l	Inorganic Nitrogen N mg/l
March 23-25	2.6	.252	.180	1.742
April 27-28	9.9	.270	.217	
June 2-3	35.5	.428	.410	1.514
July 7-8	115.0	.490	.388	1.823
Aug. 9-11	87.5	.475	.375	1.237
Sept. 14-15	62.5	.444	.388	1.889
Oct. 19-20	91.0	.744	.264	1.069
Dec. 1-2	61.0	1.178	.822	.637
Jan. 19-20	15.4	.868		3.357
Feb. 23-24	3.8	.341	.226	.835
March 23-24	17.0	.369	.223	1.677
April 25-28	14.0	.248	.136	1.124
Avg.		.509	.330	1.878

* Data from Nutrient Cruises conducted during 1965-1966 by the Chesapeake Bay Institute, the Johns Hopkins University.

FIGURE 11 POTOMAC RIVER NUTRIENTS AND CHLOROPHYLL MILE 88





phosphorus concentrations exceeded 0.25 mg/l on all occasions, and rose as high as 1.18 in December 1965.

Nitrogen

Nitrogen determinations were made in parallel with those for phosphorus (Table 14 and Figure 11). At Great Falls, Maryland, the inorganic nitrogen (N) during 1966 was 1.05 mg/l. It was never less than 0.64 mg/l at mile 88 at the time of any sample collection. The maximum value reported was 3.36 mg/l in January 1966, near Fort Washington (mile 88).

Nitrogen was more than sufficient to support abundant growths of algae.

Chlorophyll

Chlorophyll in the vicinity of Fort Washington (Table 14 and Figure 11) exceeded 50 μ g/l from July through December 1965, reaching a high of 115.0 μ g/l in July, thus indicating severe algal blooms.

BOTTOM CONDITIONS

Samples for bottom dwelling organisms and river bed materials were collected during February 1967. Stations at which samples were taken are shown in Figure 12.

Bottom Organisms

Bottom dwelling organisms are classified in three broad categories with respect to their reaction to pollution. These are: clean-water or pollution sensitive organisms that are intolerant of pollution; intermediate organisms that are tolerant of moderate pollution; and pollution-tolerant organisms. A clean stream usually supports several kinds of clean water forms, moderate numbers of intermediate forms and very few pollution-tolerant forms. Mild pollution results in loss of a few pollution-sensitive forms and a slight increase in intermediate forms. More severe pollution may eliminate all clean water forms, markedly increase intermediate forms and increase pollution-tolerant organisms. Gross pollution that is not toxic is marked by a lack of clean-water forms, a paucity of intermediate forms and a predominance of pollution-tolerant forms.

In the Potomac River from Little Falls through Little Falls Rapids (Table 15 and Figure 13), only 3 kinds of clean-water bottom animals occurred along with a few pollution-tolerant organisms. Total organism population was a sparse 40 per

square foot of rocky bottom.

At Key Bridge (mile 102.5E) there were 409 organisms per square foot, most of which were pollution-tolerant sludgeworms and bloodworms. No clean water forms occurred.

Immediately downstream from the D.C. plant (mile 95.6E), there were about 600 pollution-tolerant sludgeworms per square foot, and no clean water organisms.

About 2 miles downstream from the D.C. plant there were a limited number of intermediate forms but sludgeworms and bloodworms were found in populations of 640 and 1120 per square foot.

Moderate improvement in water quality occurred downstream as shown by the reduction in sludgeworms to less than 200 per square foot in the next eight miles of river.

At Marshall Hall and Hallowing Point bottom organisms were not a reliable indicator of pollution because of the intrusion of salt water into this reach. Both fresh and brackish water organisms occurred here.

The effects of pollution on water quality and clean-water bottom organisms, that serve as food for sport fishes, was reflected in a reduction in the fishing in this reach of the Potomac estuary. The U.S. Fish and Wildlife's Bureau of Sport Fisheries and Wildlife has estimated that pollution has caused an annual loss of 333,480 fishing man-days in the reach from Great Falls downstream to Occoquan Bay (about five miles downstream from Hallowing Point). This represents 21 percent of the total sustained fishing opportunity available in this area.

The lack of suitable bottom organisms is attributed to wastes from the District of Columbia, but bottom organisms were adversely affected also at the mouth of Hunting Creek, which receives treated sewage from Alexandria, Virginia, and in the bay at the mouth of Fourmile Run which receives treated sewage from Arlington, Virginia. Only pollution tolerant organisms were found in both locations.

The results of biological surveys on Rock Creek in August 1966 and February 1967 are presented in Table 16 and Figure 14.

In the upper reaches of Rock Creek upstream from Rockville, Maryland, there were 15 different kinds of bottom organisms, totaling nearly 100 per square foot, most of which were clean-water forms. The quality of the water decreased as it approached the District line, where 12 kinds of bottom organisms numbering 40 per square foot

Table 15
Summary of the Number of Bottom Animals Per Square Foot, Potomac River
Washington, D. C. and Maryland
1965-1967

Station (River Mile)	106.2W*	102.5E	100.7E	98.6-1.3C	96.7W	95.6E	94.0W	94.0E	91.5E	86.5E	85.0E	80.7W
POLLUTION-SENSITIVE ORGANISMS												
Stoneflies Taeniopteryx	5	-	-	-	-	-	-	-	-	-	-	-
Caddisflies Hydropsyche	2	-	-	-	-	-	-	-	-	-	-	-
Cheumatopsyche	2	-	-	-	-	-	-	-	-	-	-	-
INTERMEDIATE ORGANISMS												
Freshwater Shrimp Gammaridae	3	-	-	-	-	-	-	-	-	-	-	-
Clams Musculium	-	-	-	-	-	-	-	4	4	-	-	-
Pisidium	-	-	-	-	-	-	-	4	-	-	-	-
Unionidae	-	-	-	-	-	-	-	-	4	-	-	-
Freshwater Snails Gastropoda	Q	Q	-	-	-	-	-	-	-	-	-	-
Roundworms Nematodes	2	-	-	-	-	-	-	-	-	-	-	-
Midges Tendipedidae	22	3	5	-	-	-	6	48	276	360	384	456
Brackish Water Clams Pelecypoda	-	-	-	-	-	-	-	-	-	24	24	-
Brackish Water Sow Bugs Isopoda	-	-	-	-	-	-	-	-	-	-	-	24
Brackish Water Worms Polychaeta	-	-	-	-	-	-	-	-	-	-	-	168
POLLUTION-TOLERANT ORGANISMS												
Bloodworms Tendipes	-	5	10	-	-	-	13	32	16	24	-	-
Rat-Tailed Maggots Eristalis	-	-	-	-	-	-	-	-	-	24	-	-
Sludgeworms Tubificidae	3	400	203	74	48	614	640	1120	192	192	432	572
Total Organisms	40	409	218	74	48	614	659	1208	492	624	840	1220
Number of Kinds	8	4	3	1	1	1	3	5	5	5	3	4

* = The letters W, C, and E, denote samples obtained from west side, navigational channel, and east side of river bottom.
Q = Organisms not collected quantitatively, arbitrarily given a value of one in totals.

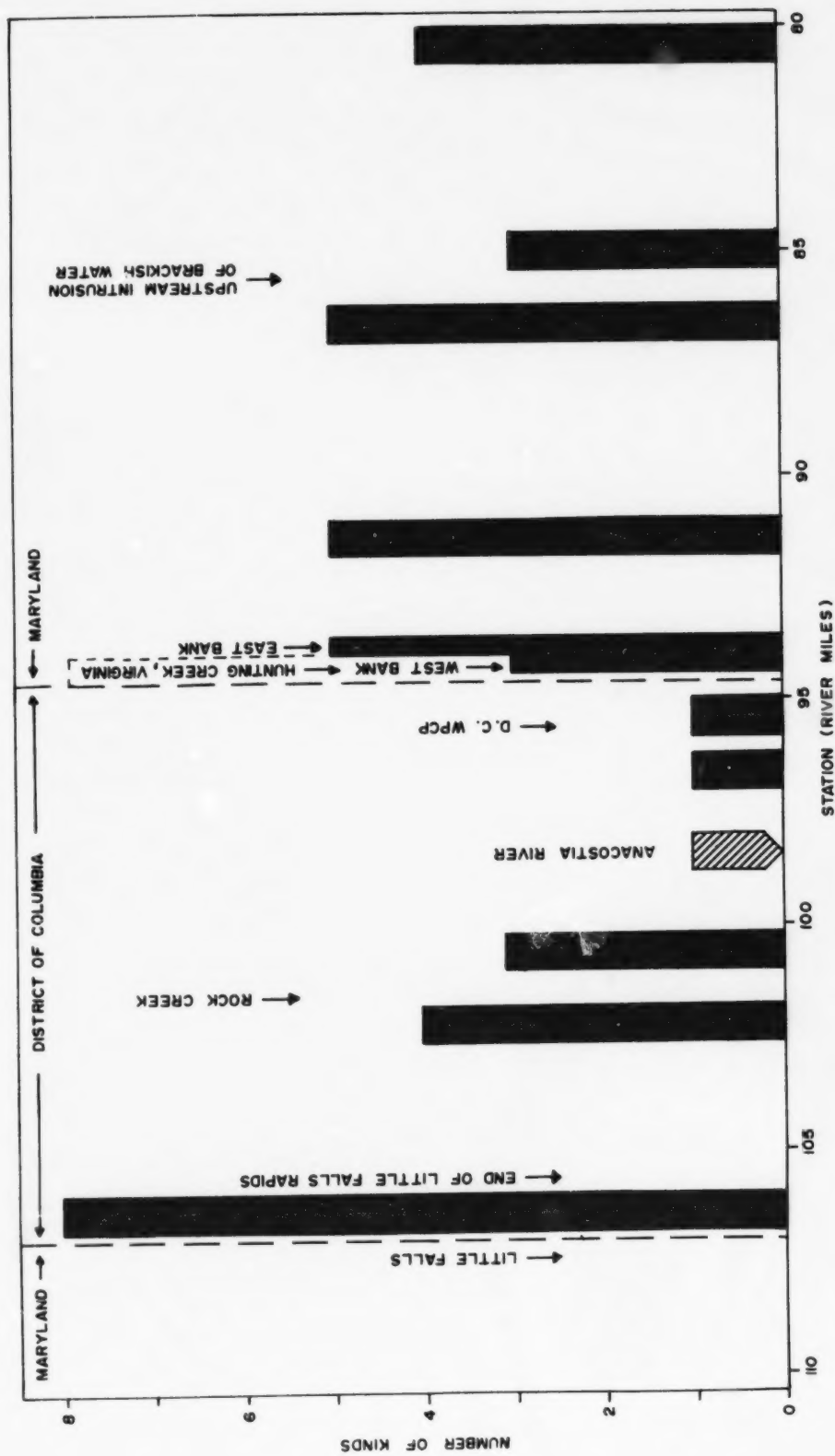


FIGURE 13 NUMBER OF KINDS OF BOTTOM ANIMALS, POTOMAC RIVER AND ANACOSTIA RIVER, MARYLAND, DISTRICT OF COLUMBIA AND VIRGINIA, 1965 & 1967

Table 16
Number of Bottom Animals Per Square Foot, Rock Creek
Maryland and Washington, D. C.
August 1966

Station (River Mile)	101.9-26.0	101.9-23.1	101.9-14.9	101.9-11.1	101.9-3.9	101.9-2.4	101.9-1.2	101.9-0.1
POLLUTION-SENSITIVE ORGANISMS								
Stoneflies								
Paragnetina	Q	—	—	—	—	—	—	—
Mayflies								
Ameletus	3	—	—	—	—	—	—	—
Stenonema	9	Q	—	—	—	—	—	—
Isonychia	8	—	—	—	—	—	—	—
Baetis	—	—	15	—	—	—	—	—
Heptagenia	—	—	1	4	—	—	—	—
Fishflies								
Chaulioides	4	3	—	—	—	—	—	—
Alderflies								
Sialis	2	—	—	—	—	—	—	—
Caddisflies								
Neophylax	—	Q	12	—	—	—	—	—
Hydropsyche	34	3	3	—	—	—	—	—
Chimarra	1	—	—	—	—	2	—	—
Riffle Beetles								
Stenelmis	15	1	—	—	—	—	—	—
Subtotal	77	9	31	4	0	2	0	0
Subtotal Kinds	9	5	4	1	0	1	0	0
INTERMEDIATE ORGANISMS								
Crawling Water Beetles								
Halipidae	—	—	—	—	1	—	—	—
Whirlygig Beetles								
Gyrinidae	—	Q	—	—	—	—	—	—
Scavenger Beetles								
Hydrophilidae	1	—	—	—	—	—	—	—
Snipe Flies								
Atherix	19	—	—	—	—	—	—	—
Crane Flies								
Antocha	1	—	—	—	—	—	—	—
Shoreflies								
Ephydra	1	—	—	—	—	—	—	16
Black Flies								
Simuliidae	—	—	Q	3	—	Q	—	—
Snails								
Physa	—	Q	Q	Q	Q	Q	3	—
Limpets								
Ferrissia	—	Q	Q	Q	Q	Q	—	—
Fingernail Clams								
Sphaerium	—	15	—	—	—	—	—	—
Roundworms								
Nematoda	—	—	—	2	—	—	—	—
Midges								
Tendipedidae	7	11	190	13	20	46	390	128
Aquatic Earthworms								
Lumbriculidae	—	Q	—	1	1	—	—	—
Leeches								
Hirudinea	—	—	—	—	3	—	—	—
Subtotal	29	30	193	21	27	49	393	144
Subtotal Kinds	5	6	4	6	6	4	2	2
POLLUTION-TOLERANT ORGANISMS								
Bloodworms								
Tendipes	—	—	Q	Q	—	Q	16	—
Sludgeworms								
Tubificidae	3	Q	3	—	—	5	71	768
Sewage Flies								
Psychoda	—	—	—	—	—	—	—	16
Subtotal	3	1	4	1	0	6	87	784
Subtotal Kinds	1	1	2	1	0	2	2	2
Grand Total	109	40	228	26	27	57	480	928
Number of Kinds	15	12	10	8	6	7	4	4

Q = Organisms not collected quantitatively, arbitrarily given a value of one in totals.
* = Samples on February 8, 1967.

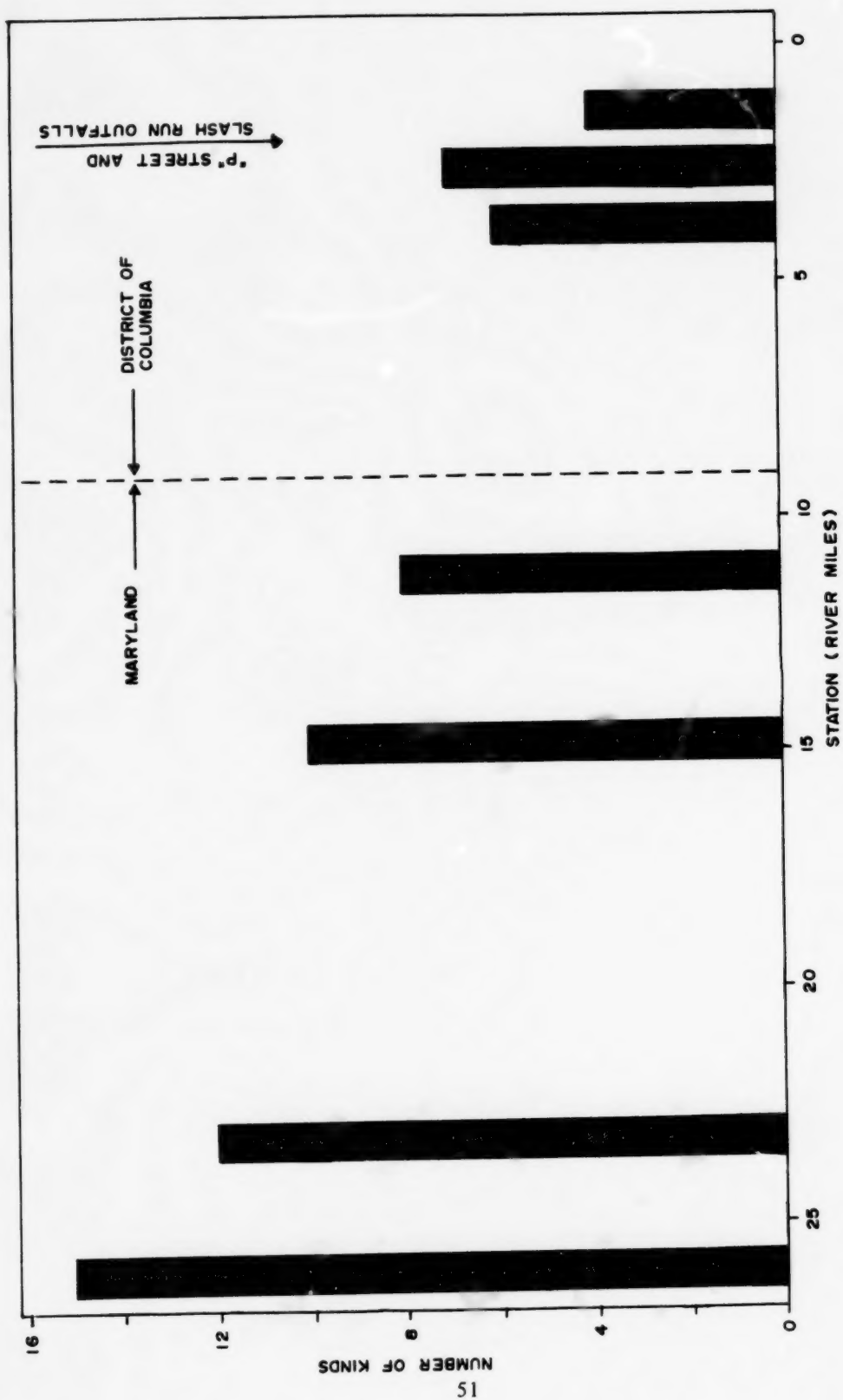


FIGURE 14 NUMBER OF KINDS OF BOTTOM ANIMALS, ROCK CREEK, MARYLAND, AND DISTRICT OF COLUMBIA, AUGUST, 1966

Table 17
Potomac River Water Turbidity
 (Jackson Candle Units)

STATION LOCATION	Above Williamsport, Maryland	At Great Falls	Arlington Memorial Bridge	Hallowing Point
Reference to D.C. Metropolitan Area	ABOVE	ENTERING	WITHIN	BELOW
River Mile	212.5	125.6	100.7	80.7

**SEVEN SUMMER SEASONS
 OF LOW RIVER FLOW**

(From Potomac River Water Quality Network)

(July, Aug. and Sept.
 during 1960-1966
 Water Years)

Seasonal Average	12	27	37	54
Minimum Monthly Average	1	10	23	30
Maximum Monthly Average	96	67	113	89
Number of months of data	19	14	21	21

1965 WATER YEAR

(From U. S. Dept. of the Interior, FWPCA, Water
 Pollution Surveillance System Data)

Mean Value	40	61	75	-
Minimum Value	25	25	23	-
Maximum Value	250	900	700	-
Number of Samples	46	52	52	0

were found east of Rockville, and 26 per square foot with only one clean water form were found near the District line. Near its mouth there were four kinds of organisms dominated by 784 sludgeworms per square foot.

The Anacostia River, 1.3 miles upstream from its mouth, supported only 74 sludgeworms per square foot. This very small number of this very pollution-tolerant organism indicated the possibility of some undetermined type of toxicity in this reach of the Anacostia, oily, oozy sludge deposits were five inches deep.

Bottom Sludges

Core samples of bottom materials revealed no slimes, oils or offensive odors in the Potomac in the vicinity of Little Falls. At Key Bridge, however, there were intermittent patches of four to six inch thick dark gray, sludge-like ooze that was covered by an inch of light brown flocculent solids.

Between Arlington Memorial Bridge and Twin Highway Bridges, there were 14 inches of compact light gray silt, covered by three inches of dark gray ooze and one inch of light brown, flocculent solids. Oil and a sewage-like odor occurred in the upper four inches of these deposits.

Just downstream from the D.C. plant, bottom deposits had a sewage odor, and contained oil, gritty vegetable matter, seeds, and scraps of paper and plastics. The deposits consisted of 13 inches of compacted, laminated sediments overlaid with 10 inches of dark black sediment and one half inch of light brown floc.

About four miles downstream from the plant there were three inches of sludge. There were about 14 inches of sludge in the mouth of Four Mile Creek, 10 inches in the bay at the mouth of Hunting Creek, and six inches in the Anacostia River.

The sludgeworm population that occurred throughout much of the Potomac estuary from Key Bridge to Halloween Point attested to the existence of organic deposits in much of this reach of the estuary. This conclusion is supported by the excessive oxygen demand of bottom deposits in much of the reach, as discussed earlier.

The total phosphorus (P) content of the sludges ranged from 0.11 to 0.27 percent of the dry weight of the sludge; the maximum occurred in the bottom deposits in the vicinity of the D.C. plant. This phosphorus contributes to nourishment of the excessive algae of the estuary. Even after

control of phosphorus in the river is achieved by adequate treatment of wastes, the phosphorus in the sludge may continue to contribute to excessive algal growths for several years, especially when sediments become resuspended in the water through turbulence.

Sludge deposits were not measured in Rock Creek, but oil, scum, slimes and foul odors occurred in bottom materials below the outfalls of the P Street combined sewer and the Slash Run interceptor in the District. Oil, sewage-like odors, sewage bacteria, brownish algal slimes and stalked protozoa, all characteristic of sewage pollution were reported near the mouth of the creek.

TURBIDITY

Available data on turbidity are shown in Table 17. At Great Falls, turbidity averaged 61 units for the year 1965. It was as low as 25 units at times, but reached a maximum of 900 units during an intense storm.

Data in Table 17 also show average monthly turbidity levels during the three recreational months (July, August, and September) 1960 through 1966. The seasonal averages for the seven years increased from 12 units at Williamsport, Maryland, in the rural area 100 miles above Washington, to 27 units at Great Falls, just upstream from the entrance of the Potomac to the estuary. The seasonal average increased to 37 units at Arlington Memorial Bridge and to 54 units at Halloween Point. The maximum monthly average during the period was 113 units at Arlington Memorial Bridge.

Turbidity is determined by measuring interference with passage of light through water. Although related to silt content, turbidity is not directly proportional to silt. This method of determination also measures the light interference by other suspended matter, such as algae and suspended solids from sewage. Algae and suspended solids undoubtedly account for at least some of the increase in turbidity through the estuary.

In their October 1957 report, "A Clean Potomac River in the Washington Metropolitan Area," Wolman, Geyer and Pyatt stated "For people living in the Washington area, silt is the worst pollutant of the Potomac River." They estimated that "the annual silt load of 60,000,000 cubic feet spread evenly to the water surface would completely fill the tidal Potomac from Chain Bridge to Fort Foote below Alexandria in 50 years."

CORRECTIVE MEASURES

Despite the considerable investments in pollution control measures that already have been made in the Washington Metropolitan Area, it is obvious that additional corrective measures are urgently needed.

Bacteria must be reduced to a very small percentage of present quantities to meet established standards and protect the health of all who come in contact with the water.

Oxygen demand must be reduced to improve DO to meet standards that will ensure propagation of desirable fish and other aquatic life, and will prevent odor nuisance.

Phosphorus must be reduced to control excessive algae and aquatic plant growths with their accompanying nuisances.

Sewage-associated suspended solids must be reduced to prevent sludge deposits that interfere with desirable bottom organisms and use needed DO.

Silt must be controlled to reduce filling of the estuary in the metropolitan area, to improve the appearance of the water and conditions for fish and other desirable aquatic life, and to ensure more desirable bathing areas.

Debris must be controlled to improve the appearance and aesthetic appeal of the river.

BACTERIA

The Maryland standard for fecal coliform bacteria requires that the average MPN density of these bacteria not exceed 240 per 100 ml at and below the District of Columbia-Maryland line.

Data on total and fecal coliform bacteria in the raw sewage of the District of Columbia, Arlington, Alexandria and Fairfax Westgate plants during February 1967, are shown in Table 18. These data were combined with average annual flows from the treatment plants (Table IV - Appendix) to calculate the permissible number of fecal coliform bacteria from each plant that would ensure adherence to the standard at the specified minimum flow of the Potomac River (7-day consecutive low flow once-in-10 years of 705 cfs).

At 1966 sewage plant flows, reduction of fecal coliform MPN densities to 42,000 per 100 ml or less in the effluents from the four plants will accomplish the necessary improvement. A reduction of about 98 percent in fecal coliform

bacteria by all sewage treatment plants will be necessary. The reduction in fecal coliforms will be accompanied by a reduction in total coliforms to a calculated density, in all plant effluents, of 255,000 per 100 ml. This can be accomplished by adequate disinfection.

As sewage plant flows increase, a corresponding decrease in effluent coliform densities will be required to meet the standards.

The calculations made no allowance for bacteria from combined sewer overflows or bypassing of raw sewage. It is assumed that these sources of bacteria will be brought under adequate control, and no longer will contribute to pollution of the estuary.

The bacteria in Rock Creek and the Anacostia River appear to be from storm water runoff, combined sewer overflows, and bypassing of sewage and not from identifiable continuous sewage discharges, either raw or treated. These two small streams will be protected from bacterial pollution only by the same types of measures that are adopted for protection of the Potomac estuary against similar sources of bacteria.

OXYGEN DEMAND AND DISSOLVED OXYGEN

The Maryland stream standards require that the DO of the Potomac average not less than 5.0 mg/l and that minimum DO be not less than 4.0 mg/l. The design flow for this standard is the same as for bacteria, the 7-day consecutive low flow once in 10 years (705 cfs).

The PE of the treated wastes from all sewage treatment plants in the metropolitan area during 1967 totalled 674,000 or a total BOD₅ of 121,000 pounds per day. The BOD₅ data for the Potomac River during the low flow months of July, August and September 1965, which have been discussed earlier, are shown on Figure 8, and are listed in Table 19. The accompanying DO, also previously discussed, is shown in Figure 10, and also is listed in Table 19.

Additional data for July, August and September for the years 1960 through 1966 are presented in Table III of the Appendix. Of these, only the 1965 data were used for calculations because the stream flow for July, August and September of that year was low and reasonably uniform.

Table 18

BACTERIOLOGICAL DATA

District of Columbia Water Pollution Control Plant

<u>Date</u>	<u>Time</u>	<u>Coliform</u>	<u>Fecal Coliform</u>
2-2-67	1415	> 16,090,000	5,420,000
2-6-67	1250	16,090,000	5,420,000
2-13-67	1145	9,180,000	790,000
2-13-67	1500	17,200,000	700,000
2-14-67	1325	5,420,000	700,000
2-14-67	1540	17,200,000	2,300,000
2-15-67	0915	34,800,000	10,900,000
2-15-67	1225	17,200,000	4,600,000
Geometric Average		14,800,000	2,450,000

Arlington Sewage Treatment Plant

<u>Date</u>	<u>Time</u>	<u>Coliform</u>	<u>Fecal Coliform</u>
2-2-67	1140	2,400,000	790,000
2-3-67	1020	3,480,000	1,300,000
2-3-67	1310	5,420,000	1,300,000
2-6-67	1340	24,000,000	5,420,000
2-6-67	1455	16,090,000	16,090,000
2-13-67	1015	5,420,000	2,400,000
2-13-67	1330	2,400,000	2,400,000
2-14-67	1200	3,480,000	700,000
2-14-67	1415	9,400,000	2,100,000
2-15-67	1020	3,480,000	2,400,000
2-15-67	1310	3,480,000	3,480,000
Geometric Average		5,290,000	2,270,000

Table 18 (contd.)

BACTERIOLOGICAL DATA

Alexandria Sewage Treatment Plant

<u>Date</u>	<u>Time</u>	<u>Coliform</u>	<u>Fecal Coliform</u>
2-2-67	1215	5,420,000	490,000
2-3-67	1050	1,720,000	110,000
2-3-67	1340	9,180,000	5,420,000
2-6-67	1410	16,090,000	3,480,000
2-6-67	1525	17,200,000	2,400,000
2-13-67	1045	10,900,000	700,000
2-13-67	1400	16,090,000	1,720,000
2-14-67	1230	16,090,000	460,000
2-14-67	1445	10,900,000	800,000
2-15-67	1050	16,090,000	9,180,000
2-15-67	1340	9,180,000	3,480,000
Geometric Average		10,100,000	1,380,000

Fairfax Westgate Sewage Treatment Plant

<u>Date</u>	<u>Time</u>	<u>Coliform</u>	<u>Fecal Coliform</u>
2-2-67	1330	542,000	49,000
2-3-67	1120	< 2,000	< 2,000
2-3-67	1400	< 2,000	< 2,000
2-13-67	1110	< 20,000	< 20,000
2-13-67	1430	20,000	< 20,000
2-14-67	1250	< 20,000	< 20,000
2-14-67	1510	< 20,000	< 20,000
2-15-67	1115	500	< 200
2-15-67	1400	< 200	< 200

Table 19

POTOMAC ESTUARY

Oxygen Demand and Dissolved Oxygen - July, August, and September 1965

Station	River Mile	BOD ₅ , mg/l			D.O., mg/l		
		Max.	Avg.	Min.	Max.	Avg.	Min.
Fletcher's Boathouse	104.5	5.8	2.7	1.0	9.6	7.4	6.0
Three Sisters Islands	103.1	4.2	2.0	0.2	8.7	7.1	5.4
Roosevelt Island	101.6	5.6	1.9	0.4	7.5	5.5	3.2
Memorial Bridge	100.7	3.6	1.5	0.2	8.3	5.6	3.5
Twin Highway Bridges	99.7	4.2	2.5	0.6	9.1	5.8	3.5
Mid-Potomac Park	99.1	6.2	2.7	0.2	9.0	5.7	3.3
Hains Point	98.3	11.4	6.9	3.2	10.4	4.3	1.2
Giesboro Point	97.4	15.1	8.8	3.0	7.0	3.5	0.9
Above D.C. STP	96.1	14.4	9.1	2.0	7.5	3.3	1.1
Opposite D.C. STP	95.6	15.0	10.6	7.0	5.9	2.8	0.4
Below D.C. STP	95.3	14.7	9.7	2.6	6.0	2.9	0.7
Woodrow Wilson Bridge	94.4	14.6	9.9	4.8	5.3	3.0	1.2
Fort Foote	92.9	15.0	9.2	5.4	5.7	3.2	1.6
Fort Washington	89.0	13.6	7.3	2.4	6.6	3.8	1.5
Marshall Hall	85.0	10.4	6.9	3.6	8.4	5.4	3.4
Hallowing Point	80.7	7.2	5.6	3.8	8.3	6.8	5.1

In addition to the foregoing data, an upstream BOD_5 of 2.0 mg/l, the observed bottom oxygen demand (Figure 9), and a stream temperature of 29 degrees C. were assumed for calculations of the BOD_5 load that can be discharged to the estuary to maintain an average DO of 5 mg/l. Calculations were based on the assumption that discharges will continue at the present locations.

A general description of the method used to calculate the assimilative capacity of the estuary is included in the Appendix.

Initial calculations revealed that the existing bottom demands alone would reduce the DO below 5.0 mg/l at low flows. Subsequent calculations assumed that the necessary additional treatment would reduce the bottom oxygen demand ultimately to the 1 gram per square meter per day rate that is typical of an unpolluted estuary.

These calculations based on present discharge locations indicated that the 5-day BOD of all wastes discharged in the metropolitan area must be reduced to less than 16,500 pounds per day from the existing 121,000 pounds per day, or an additional reduction of 86 percent. The overall reduction of BOD_5 required from the total raw sewage load is 96 percent. It was assumed during the calculations that an 85 percent reduction in nitrogenous BOD would simultaneously occur.

The calculated average DO of the Potomac estuary that would result from the reduced BOD load is shown in Figure 15. The residual oxygen demand from upstream would cause a reduction in the DO of the water entering the estuary to a 5.9 mg/l near Arlington Memorial Bridge. This would be followed by an increase in DO to 6.2 mg/l above the D.C. plant. The D.C. plant effluent would cause a drop in DO to 5.0 mg/l below the plant, followed by recovery to 6.9 mg/l in the vicinity of Fort Washington.

Here again, as in the case of bacteria, no allowance was made for BOD from combined sewer overflows, or bypassing of sewage. It is assumed that these sources will be brought under control by other means.

The additional reduction in BOD_5 would ensure the maintenance of the average 5.0 mg/l DO standard. The frequency distribution of DO values in the critical reach of the river for July through September, 1960 through 1966, was determined and is plotted in Figure 16. There were several causes of the DO variations in the estuary during the years 1960 through 1966. One of the causes was the variations in treatment plant

efficiencies. For example, monthly averages of BOD_5 removal by the District of Columbia Plant in 1966 varied from 13.5 to 74.3 percent, with an annual average of 56.6 percent. Other contributing factors included the bypassing of sewage and combined sewer overflows. The significance of controlling these causes is shown in Figure 16. If these same DO variations were to occur following the necessary remedial measures, the minimum standard of 4.0 mg/l would be violated during 26 days, or 28 percent of the time during the period July through September. More consistent operation of waste treatment plants along with greater reductions in oxygen demand, and the elimination of sewage bypassing, and combined sewer overflows must be accomplished to reduce the DO variations.

PHOSPHORUS

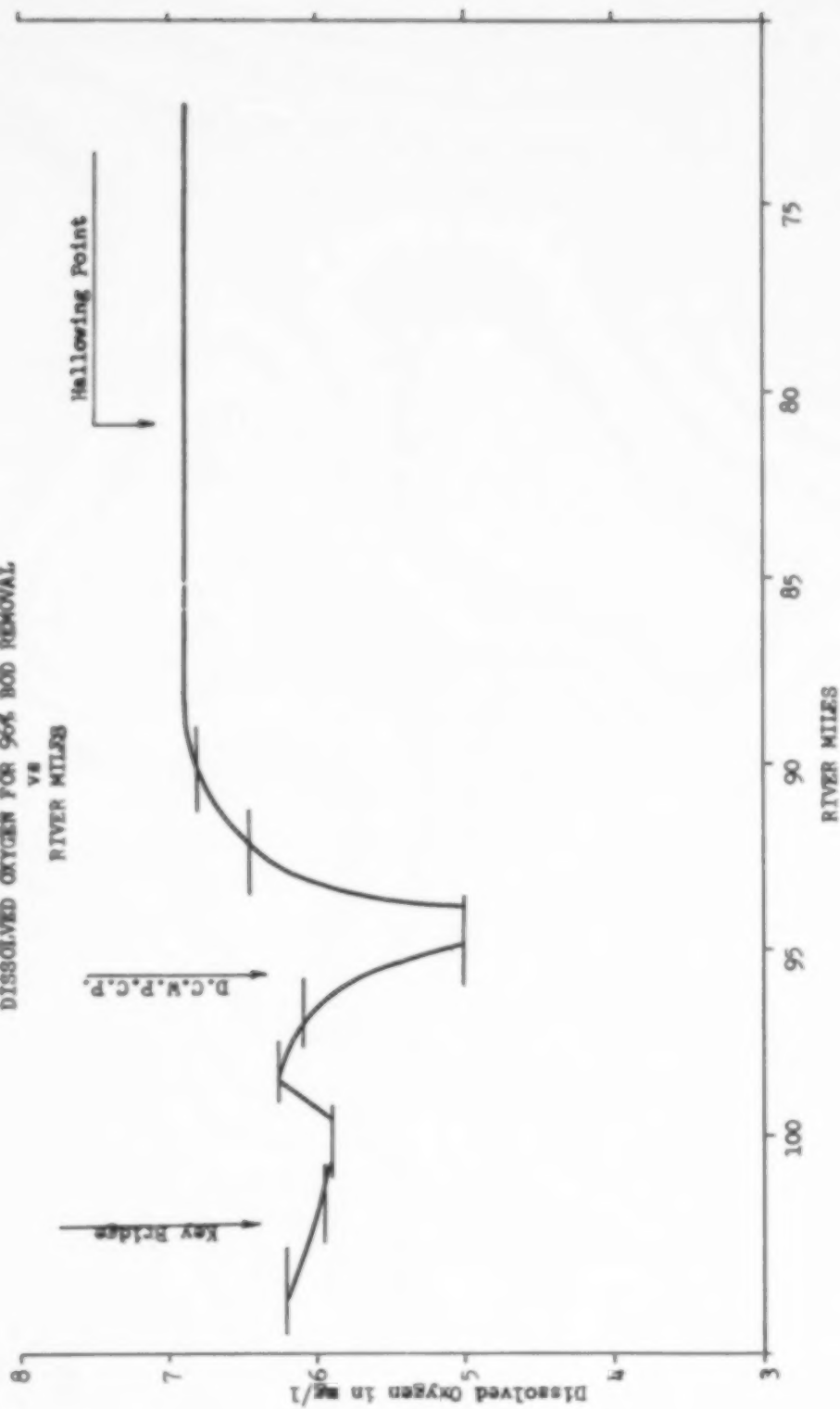
The need to control phosphorus discharged to the Potomac estuary as a means of controlling excessive algal growths has been discussed previously. It has been concluded, based on observations in the estuary, that limiting the total phosphorus concentration in the stream to 0.1 mg/l (as P) will limit algal growths to tolerable levels.

Total phosphorus was determined in the raw sewage of the four major systems. The relatively small quantity of other sources of sewage was estimated on the basis of a per capita contribution of 0.01 pounds of phosphorus per capita per day. Combination of the two sets of values gives an estimated total of 21,100 pounds of phosphorus in the raw sewage of the metropolitan area.

Phosphorus is removed from solution in water by both physical absorption on suspended matter, and by incorporation in the bodies of aquatic plants and animals. In both cases the end result is that the phosphorus ultimately settles to the bottom of the stream. Observations in the Potomac estuary indicate that these mechanisms may reduce the phosphorus concentration in water to 0.03 mg/l, but not below.

At the design river flow of 705 cfs, and based on the foregoing considerations and the present discharge location, it was calculated that discharge of phosphorus to the Potomac estuary in the metropolitan area must be limited to 740 pounds per day if excessive algal growths are to be avoided. Achieving this would necessitate 96.5 percent reduction in phosphorus of the raw sewage at all treatment plants.

Figure 15
POTOMAC RIVER ESTUARY
DISSOLVED OXYGEN FOR 96% BOD REMOVAL



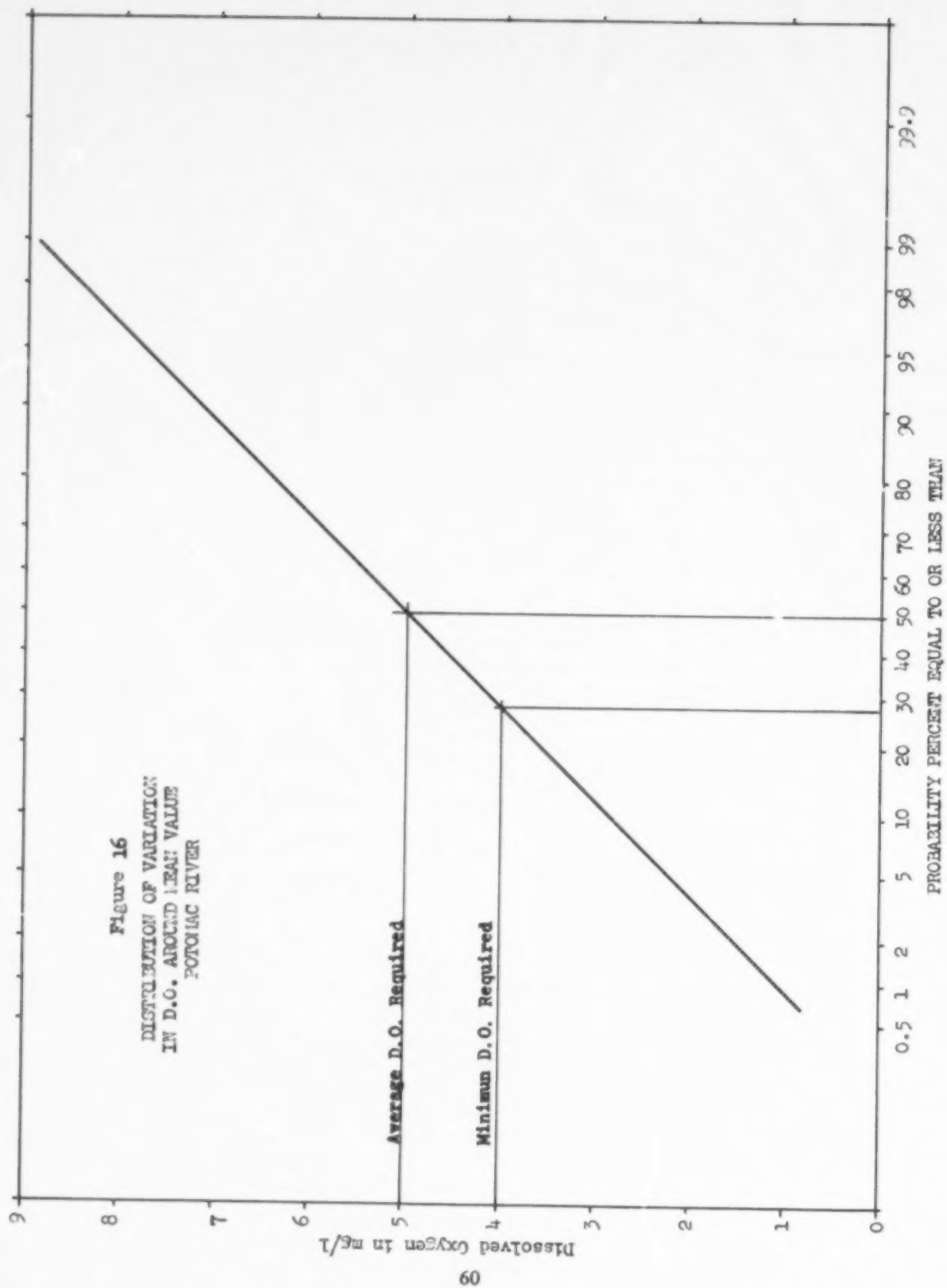
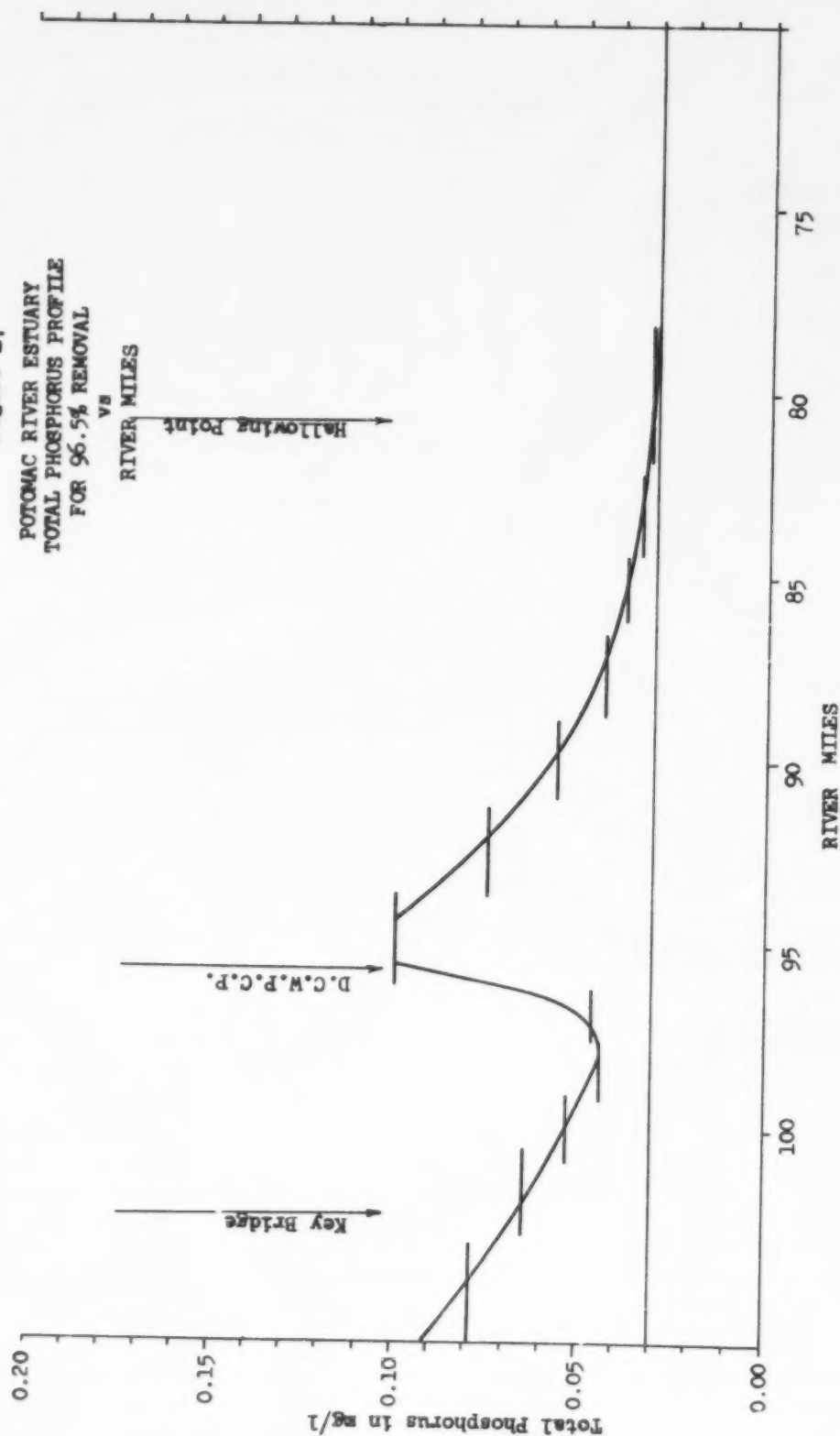


Figure 17
POTOMAC RIVER ESTUARY
TOTAL PHOSPHORUS PROFILE
FOR 96.5% REMOVAL



The estimated phosphorus in the estuary following the recommended reduction is shown in Figure 17. The 0.09 mg/l of phosphorus entering the estuary from upstream would drop to 0.044 mg/l near Giesboro Point. A sharp rise in phosphorus to 0.10 mg/l would occur in the vicinity of the D.C. plant. This would be followed by a slow decline to the minimum level of 0.03 mg/l near Marshall Hall.

MULTIPLE DISPOSAL POINTS

The major effects of treated waste discharges peak at the outfall of the District of Columbia's plant. Calculations of waste assimilation capacity of the estuary (16,500 lb/day BOD₅), and BOD₅ and phosphorus removals (96 percent each) were based on the continued discharge by the District of Columbia's plant at the existing single outfall. Present technology can provide the degree of treatment needed by means of advanced waste treatment facilities requiring a consistent and highly efficient operation.

The high degree of treatment needed is based on maintaining the above-mentioned peak within the required limits at low flow conditions. Figures 15 and 17, based on concentrations in the estuary following the accomplishment of these high degrees of treatment indicate a recovery of the estuary in a relatively short distance (5-10 miles) downstream. An evaluation should be made of the feasibility of establishing multiple points along the estuary to discharge the District of Columbia Water Pollution Control Plant's wastes, rather than through the existing single discharge point. This evaluation should determine the possible advantages of such a measure to total estuarine water quality. Should this means prove feasible, such discharges can only follow the highest degree of treatment practicable, including phosphorus removal.

SLUDGE DEPOSITS

The sludge deposits should be effectively controlled by two prospective improvements in waste disposal. The recommended improvement in BOD removal by additional sewage treatment also will improve removal of the organic suspended solids that have been contributing to sludge deposits. Completion of the program for control of combined sewer discharges and of the bypassing of raw sewage will reduce the raw sewage solids that contributed to sludge deposits.

As discussed elsewhere, several years probably will elapse before existing sludge deposits stabilize and their effects on oxygen demand and on fish and aquatic life are reduced.

SILT

The successful control of silt cannot be accomplished by an individual locality acting independently. The widespread distribution of sources and of those responsible for the sources renders it imperative that a major cooperative effort be mounted if success is to be achieved.

Numerous municipal, county, state and interstate agencies and interested local associations presently conduct various soil erosion and sediment control programs. Municipal sewage treatment plants reduce the suspended solids content of waste waters. Soil conservation districts seek to keep the soil in place on the land. There are state and county laws and regulations designed to control erosion and promote recovery of strip mining areas.

Federal agencies are involved in soil conservation, management and restoration activities. The Department of Agriculture provides soil erosion control assistance on privately owned lands and in national forests. The National Park Service manages national monuments and the Fish and Wildlife Service provides Federal aid for wildlife restoration. The Bureau of Public Roads, working with the American Association of State Highway Officials, is preparing guidelines for improved highway construction practices to reduce erosion. The Corps of Engineers dredges navigation channels and provides storage space for sediment in reservoirs.

In their 1957 report, Wolman, Geyer and Pyatt recommended a large reservoir on the Potomac above Great Falls as a portion of a comprehensive sediment control program. The Corps of Engineers had proposed construction of the Seneca Reservoir, a multi-purpose project, above Great Falls, in their comprehensive program for development of water resources of the Potomac River Basin. This proposal met with much opposition, both private and official. The Secretary of the Interior's "Potomac Interim Report to the President" included in its recommendations "that Seneca Dam and Reservoir on the main stem of the Potomac not be constructed at this time, but that its site be preserved to the maximum feasible degree at its present level of economic development."

In addition to other programs already in progress, the "Report to Inter-Departmental Task Force on the Potomac by the Sedimentation and Erosion Sub-Task Force," May 1967, proposed an accelerated 10 yr. program for the control of erosion and sedimentation in the basin. The "Conclusions and Summary of Recommendations" of the Report are included in

the Appendix. The recommended work consists of: surveys, planning and demonstration projects; highway construction controls and roadside stabilization; and technical assistance and construction of sediment control basins throughout the Potomac River Basin. The estimated costs are:

	Federal	Non-Federal	Total
Urban activities	\$58,100,000	\$5,990,000	\$64,090,000
Rural and basin-wide activities	134,284,000	41,859,000	176,143,000
Strip mine reclamation	9,000,000	1,000,000	10,000,000
Total	\$201,384,000	\$48,849,000	\$250,233,000

Of the total cost about one-third, \$78,300,000 would be devoted to construction of sediment control basins. About two-thirds of this sum would be required in the most critical area of the Potomac basin, that in the vicinity of the District of Columbia.

The estimated reduction in silt reaching the streams of the basin that would be accomplished by the proposed program is:

Category	Percent of Total Silt
Basin-wide activities	6.5
Rural Controls	14.0
Urban Controls	24.0
Strip Mine Reclamation	3.0
Total	47.5

The total \$250,000,000 cost of the program would accomplish much more than reduce the silt to the streams by almost one-half. An even greater benefit would result from the conservation of land and water resources and enhancement of land values in regions made more attractive by eliminating scars of erosion. Agricultural lands would be protected, wildlife habitats improved,

and the pursuit of recreation would become more enjoyable and satisfying. Estuary dredging would be reduced.

RAW SEWAGE DISCHARGES

The District of Columbia's long-term program for control of raw sewage discharges from combined sewers and overloaded sewers already has been discussed. Commendable progress has been made, and a major portion of the program is scheduled for completion by 1969. Only the separation of sanitary and storm sewers that account for an estimated 22 percent of the raw sewage discharge will remain. Completion of this phase of the program is scheduled for the year 2000. This program should be continued and final completion date advanced: or other means of removing these raw sewage discharges accomplished.

AESTHETIC VALUES

Completion of projects already underway or recommended in this report will result in reduction of significant quantities of the repulsive sewage solids that intermittently litter the surface of the Potomac River estuary.

As long as storm sewers and surface runoff discharge to the Potomac, debris from natural and urban sources still will reach the estuary. Implementation of the recommended silt control program would accomplish some reduction in the debris from natural and urban sources, but would not eliminate it. A regular program of policing and removing such residual debris will be necessary for full protection of the scenic beauty of the Potomac.

"Operation Clean Waters," a cooperative effort of the Government of the District of Columbia and the Federal government, utilizes enrollees of the Neighborhood Youth Corps to remove debris littering the banks of the Potomac and Anacostia Rivers and Rock Creek. Removing the material and debris contributes to the aesthetic value and reduces water pollution and safety hazards.

* * * * *

APPENDIX

Table I-A

POTOMAC RIVER IN THE WASHINGTON D. C. METROPOLITAN AREA
WATER QUALITY STANDARDS

Potomac River	Zone	State	Uses	Bact.	D.O.	Criteria Temp.	pH
Main Stem in Montgomery (Md.) County (to D.C. line)		Maryland	Public or municipal water supply	A-3	B-3	C-3	D-1
			Water contact recreation	A-4			
			Propagation of fish, other aquatic life and wildlife				
			Agricultural water supply				
			Industrial water supply				
			Fish and wildlife propagation	A-1	B-1	C-1	D-1
			Recreational boating				
			Industrial water supply				
			Water contact recreation				
			Maintenance of fish life	—	B-2	C-1	D-1
Key Bridge to D.C.—Prince Georges (Md.) County line		D.C. 1/ D.C.	Recreational boating				
			Industrial water supply				
			Water contact recreation				
			Propagation of fish, other aquatic life and wildlife	A-4	B-3	C-3	D-1
D.C. line to Upper Cedar Point		Maryland	Industrial water supply				
			Water contact recreation				
			Propagation of fish, other aquatic life and wildlife				
			Industrial water supply				
Rock Creek		Maryland	Water contact recreation				
			Propagation of fish, other aquatic life and wildlife	A-4	B-3	C-3	D-1
			Agricultural water supply				

Table I-A (Cont.)

Zone	State	Uses	Bact.	Criteria		
				D.O.	Temp.	pH
Rock Creek (Cont'd.)						
Detention Dam # 5 to Norbeck Rd. (Rt. # 28)	Maryland	Water contact recreation Propagation of fish, other aquatic life and wildlife (trout) Agricultural water supply	A-4	B-3	C-3	D-1
Upstream of Dam #1	Maryland	Water contact recreation Propagation of fish, other aquatic life and wildlife (trout) Agricultural water supply	A-4	B-3	C-3	D-1
Norbeck Rd. (Rt. # 28) to D.C. - Montgomery (Md.) County line	Maryland	Water contact recreation Propagation of fish, other aquatic life and wildlife	A-4	B-3	C-3	D-1
D.C. - Montgomery (Md.) County line to Potomac River	D.C. 1/ D.C.	Fish and wildlife propagation Wading (additional criteria*)	A-2	B-1	C-2	D-1
* Turbidity - Creek bottom visible in wading areas.						
Anacostia River						
Confluence of Northeast and Northwest Branches to D.C. line	Maryland	Water contact recreation Propagation of fish, other aquatic life and wildlife Industrial water supply	A-4	B-3	C-3	D-1

* Turbidity - Creek bottom visible in wading areas.

Table I-A (Cont.)

Zone	State	Uses	Criteria			
			Bact.	D.O.	Temp.	pH
Anacostia River (Cont'd.)						
D.C.-Prince Georges (Md.) County line to Potomac confluence	D.C. ^{1/}	Maintenance of fish life Recreational boating Industrial water supply	—	B-2	C-1	D-1
Oxon Run						
Maryland sections to mouth	Maryland	Water contact recreation Propagation of fish, other aquatic life and wildlife	A-4	B-3	C-3	D-1
D.C. line at Mississippi Ave., S.E. to D.C. line in vicinity of Nichols Ave., S.W.	D.C. ^{1/}	Fish and wildlife propagation	—	B-2	C-1	D-1

1/ The Secretary of the Interior excepted the dissolved oxygen and temperature criteria proposed in the District's water quality standards and recommended an early addition to the District's bacteriological water quality standards. Further, to better protect secondary contact recreation water uses (such as fishing and boating), appropriate bacteriological criteria should be adopted for the Potomac River below Key Bridge and the Anacostia River.

Table II-A

Code	Criteria
A-1	Fecal Coliform – Not to exceed 240/100 ml. in 90% of the samples collected each month.
A-2	Fecal Coliform – No. do exceed 200/100 ml.
A-3	Public or Municipal Water Supply Uses – Monthly average value (either MPN or MF count) of coliform organisms not to exceed 5,000 per 100 ml. of sample; nor to exceed this number in more than 20% of the samples examined during any month; nor exceed 20,000 per 100 ml. in more than 5% of such samples. There must be no discharges of sewage, industrial waste or other waste that deleteriously affect the safety of the water supply and which could, in this manner, contravene the latest edition of the PUBLIC HEALTH SERVICE DRINKING STANDARDS (published by U.S. Public Health Service).
A-4	water Contact Recreation Uses – The bacterial quality of water is acceptable for these uses when a sanitary survey reveals no source of dangerous pollution and when the fecal coliform organism density does not exceed 240 MPN per 100 ml. When the fecal coliform organism density exceeds 240 MPN per 100 ml., the bacterial water quality shall be considered acceptable only if a second detailed sanitary survey and evaluation discloses no significant public health risk in the use of the waters.
B-1	Dissolved Oxygen – Not less than 4 mg/l.
B-2	Dissolved Oxygen – Not less than 3 mg/l.
B-3	For "trout waters," waters so designated to the Department by the Department of Game and Inland Fish, the dissolved oxygen concentration must not be less than 5.0 mg. per liter at any time, with a minimum monthly average of not less than 6.0 mg. per liter. For the propagation of fish and other aquatic life (Water Use Category IV) in all other waters, the dissolved oxygen concentration must not be less than 4.0 mg. per liter at any time, with a minimum monthly average of not less than 5.0 mg. per liter, except where—and to the extent that—lower values occur naturally. Any deviation, other than natural, from the above requirements is to be evaluated for risk to the propagation of fish and other aquatic life by the Department of Game and Inland Fish for nontidal waters, and by the Department of Chesapeake Bay Affairs for tidal waters, and will be permitted or denied by the Department of Water Resources after consultation with the aforementioned agencies.
C-1	Temperature – Not to exceed 93°F. There shall be no sudden or localized temperature changes that may adversely affect aquatic life.
C-2	Temperature – Not to exceed natural conditions.

Table II-A (Cont.)

Code	Criteria
C-3	FOR NONTIDAL WATERS: For "trout waters," waters so designated to the Department by the Department of Game and Inland Fish, temperature must not exceed 72°F. at any time. For the propagation of fish and other aquatic life (Water Use Category IV) in all other nontidal waters, temperature must not exceed 93°F. beyond such distance from any point of discharge as specified by the Department as necessary for the protection of the water use. In addition for all nontidal waters other than "trout waters," maximum temperature elevation is to be limited as follows: For natural water temperatures of 50°F., or less, the temperature elevation must not exceed 20°F. above the natural water temperature, with a maximum temperature of 60°F. For natural water temperatures greater than 50°F., the temperature elevation must not exceed 10°F. above the natural water temperature, with a maximum temperature of 93°F. Any deviation, other than natural, from the above requirements is to be evaluated for risk to the propagation of fish and other aquatic life by the Department of Game and Inland Fish, and will be permitted or denied by the Department of Water Resources after consultation with that agency. FOR TIDAL WATERS used for the propagation of fish and other aquatic life (Water Use Category IV), temperature must not exceed 90°F. beyond such distance from any point of discharge as specified by the Department as necessary for the protection of the water use. In addition, for all tidal waters, maximum temperature elevation is to be limited as follows: For natural water temperatures of 50°F., or less, the temperature elevation must not exceed 20°F. above the natural water temperature, with a maximum temperature of 60°F. For natural water temperature greater than 50°F., the temperature elevation must not exceed 10°F. above the natural water temperature, with a maximum temperature of 90°F. Any deviation, other than natural, from the above requirements is to be evaluated for risk to the propagation of fish and other aquatic life by the Department of Chesapeake Bay Affairs, and will be permitted or denied by the Department of Water Resources after consultation with that agency.
D-1	pH 6.0 - 8.5

Table III-A
POTOMAC RIVER

Data Summary for
July, August, and September

1960 - 1966

YEAR	Temp. °C.	5-day BOD mg/l	D.O. mg/l	Total Coliform MPN/100ml		Chlorides mg/l	Turbidity Units	
				Geom.	Arith.			
Fletcher's Boat House (R.M. 104.5)								
1963	1960	26.2	2.0	7.3	1,690	4,570	10	36
	1961	28.0	2.2	7.5	530	1,470	16	33
	1962	22.9	1.7	7.7	1,280	2,260	23	28
	1963	25.1	1.8	7.2	1,760	9,410	21	44
	1964	23.8	2.0	7.8	1,550	9,220	25	30
	1965	26.5	2.7	7.4	1,690	4,230	26	36
	1966	26.1	1.5	5.7	3,130	13,020	31	27
Three Sisters Islands (R.M. 103.1)								
	1960	25.6	1.9	7.4	930	2,410	13	25
	1961	28.2	2.0	7.8	625	1,070	17	25
	1962	25.1	2.8	7.7	660	1,360	21	27
	1963	25.0	1.7	6.6	3,290	16,900	21	58
	1964	23.8	1.8	7.6	1,450	7,460	25	26
	1965	26.3	2.0	7.1	2,150	4,410	26	42
	1966	25.9	1.6	5.7	3,250	6,840	28	31
Roosevelt Island (R.M. 101.6)								
	1960	25.4	1.9	7.1	5,740	14,240	11	27
	1961	28.0	1.9	7.8	2,030	6,430	15	27
	1962	25.0	2.2	7.6	2,620	6,300	23	28
	1963	25.2	2.4	6.1	6,780	14,800	21	56
	1964	23.9	2.9	6.5	19,900	79,150	22	34
	1965	26.1	1.9	5.5	18,850	46,560	25	42
	1966	25.8	3.3	4.6	44,000	160,000	30	36
Arlington Memorial Bridge (R.M. 100.7)								
	1960	25.6	1.9	6.7	4,780	8,570	13	27
	1961	28.0	2.2	7.5	2,480	9,660	16	31
	1962	24.9	2.1	7.2	2,660	6,100	30	28
	1963	25.2	1.6	5.9	4,800	25,340	21	58
	1964	24.0	2.3	6.3	18,000	49,600	26	25
	1965	26.2	1.5	5.6	11,860	18,660	25	41
	1966	25.7	2.8	4.9	12,050	54,300	29	46

Table III-A (Cont.)
 FOTOMAC RIVER
 Data Summary for
 July, August, and September
 1960 - 1966

YEAR	Temp. °C.	5-day BOD mg/l	D.O. mg/l	Total Coliform MPN/100ml		Chlorides mg/l	Turbidity Units
				Geom.	Arith.		
Fort Foote (R.M. 92.9)							
1960	26.0	3.7	4.1	11,700	68,050	12	33
1961	28.2	3.8	4.1	18,000	47,090	16	34
1962	25.0	5.7	2.5	39,600	41,400	27	32
1963	25.3	6.7	2.8	3,260	7,830	26	37
1964	24.8	8.2	2.5	43,000	187,400	27	37
1965	26.8	9.2	3.2	48,100	105,000	31	57
1966	26.2	10.0	3.0	189,000	282,000	37	52
Fort Washington (R.M. 89.0)							
1960	26.0	4.2	4.7	1,370	2,340	11	36
1961	27.8	4.6	4.6	2,900	9,680	16	38
1962	24.7	4.4	3.2	1,120	1,480	25	36
1963	25.1	6.5	4.0	670	1,470	34	47
1964	24.5	7.4	3.8	1,180	2,030	29	39
1965	26.6	7.3	3.8	3,750	5,860	35	60
1966	26.0	7.6	4.4	10,800	19,300	48	53
Marshall Hall (R.M. 85.0)							
1960	26.0	3.9	5.4	1,310	2,280	11	41
1961	27.6	4.6	5.8	1,320	2,110	17	41
1962	24.6	4.6	4.6	1,150	1,700	29	73
1963	24.9	6.0	6.1	300	1,770	85	49
1964	24.2	6.7	6.1	150	220	41	50
1965	25.9	6.9	5.4	220	760	57	52
1966	25.9	5.5	5.6	470	2,990	112	60
Hallowing Point (R.M. 80.7)							
1960	26.1	4.0	6.6	1,070	1,800	10	40
1961	27.4	4.8	6.9	252	2,770	18	47
1962	24.3	4.4	6.5	1,130	3,600	41	49
1963	24.6	6.9	7.5	380	5,470	199	64
1964	24.0	6.8	7.1	60	170	72	58
1965	25.9	5.6	6.8	140	950	93	60
1966	25.8	4.8	6.8	240	2,420	177	62

Table III-A (Cont.)

POTOMAC RIVER

Data Summary for
July, August, and September

1960 - 1966

YEAR	Temp. °C.	5-day BOD mg/l	D.O. mg/l	Total Coliform MPN/100ml		Chlorides mg/l	Turbidity Units
				Geom.	Arith.		
Above D.C. – W.P.C.P. (R.M. 96.1)							
1960	25.6	3.0	4.2	63,900	136,150	12	35
1961	28.4	4.6	4.5	75,700	143,750	16	38
1962	25.3	7.4	3.7	98,100	189,000	25	47
1963	25.3	6.7	2.8	32,500	61,000	24	107
1964	25.0	7.9	2.5	76,750	151,200	26	33
1965	26.8	9.1	3.3	521,000	2,971,000	29	61
1966	26.3	11.0	3.1	158,000	228,000	32	53
Opposite D.C. – W.P.C.P. (R.M. 95.6)							
1960	25.9	2.4	4.6	19,700	29,920	11	39
1961	28.5	3.9	4.9	79,400	152,000	16	46
1962	25.8	5.5	4.4	68,600	152,000	23	40
1963	25.7	6.8	2.8	22,600	51,750	25	56
1964	25.3	7.7	4.5	68,400	141,700	25	38
1965	26.9	10.6	2.8	130,000	366,910	29	64
1966	26.9	11.0	4.1	302,000	611,000	31	62
Below D.C. – W.P.C.P. (R.M. 95.3)							
1960	25.8	4.0	3.9	81,000	407,150	12	42
1961	28.4	4.8	4.7	217,000	703,000	17	35
1962	25.6	6.5	3.5	97,500	148,000	25	33
1963	25.4	6.6	2.6	31,100	53,100	25	45
1964	25.1	8.5	3.0	150,000	500,000	26	33
1965	26.8	9.7	2.9	118,000	217,640	31	60
1966	26.6	10.4	2.9	498,000	862,000	32	54
Woodrow Wilson Bridge (R.M. 94.4)							
1960	-	-	-	-	-	-	-
1961	-	-	-	-	-	-	-
1962	25.4	5.9	2.9	31,800	35,800	30	34
1963	25.4	6.6	2.6	52,200	78,440	27	48
1964	25.5	9.2	2.7	96,800	277,000	27	34
1965	26.6	9.9	3.0	50,700	99,730	30	55
1966	26.4	11.1	2.5	167,500	214,000	35	54

Table III-A (Cont.)

POTOMAC RIVER

Data Summary for
July, August, and September

1960 - 1966

YEAR	Temp. °C.	5-day BOD mg/l	D.O. mg/l	Total Coliform MPN/100ml		Chlorides mg/l	Turbidity Units
				Geom.	Arith.		
Twin Highway Bridge (R.M. 99.7)							
1960	25.6	1.9	6.8	4,000	6,910	14	29
1961	28.0	1.9	7.2	8,700	20,540	16	33
1962	24.9	1.9	6.9	4,230	9,000	23	29
1963	25.2	2.3	5.4	7,100	29,000	21	56
1964	23.9	2.2	5.6	13,500	34,900	23	33
1965	26.3	2.5	5.8	13,460	20,290	24	43
1966	25.7	3.0	5.6	11,100	84,100	27	53
Mid-Potomac Park (R.M. 99.1)							
1960	25.5	1.8	6.6	3,450	6,590	11	38
1961	28.0	2.3	7.5	4,150	12,040	14	35
1962	25.0	3.0	7.0	1,120	3,380	25	29
1963	25.3	3.2	5.5	4,960	25,540	22	54
1964	24.2	2.7	5.7	9,240	36,250	25	38
1965	26.3	2.7	5.7	3,600	5,090	26	46
1966	25.8	3.9	5.3	5,380	10,380	28	53
Hains Point (R.M. 98.3)							
1960	25.5	2.0	6.0	7,730	12,520	11	39
1961	28.1	3.1	7.3	3,550	9,790	14	36
1962	25.2	3.1	6.5	2,340	5,890	21	32
1963	25.5	4.4	4.0	9,950	46,040	20	51
1964	24.2	3.6	5.8	3,520	6,920	24	41
1965	26.5	6.9	4.3	20,900	100,280	28	73
1966	25.9	4.7	5.2	7,480	13,750	28	64
Giesboro Point (R.M. 97.4)							
1960	25.5	2.1	4.8	25,500	60,100	13	32
1961	28.1	3.0	5.4	24,100	95,900	16	40
1962	25.3	3.7	5.1	6,850	12,550	21	33
1963	25.5	5.5	3.3	26,200	64,240	23	48
1964	25.0	5.4	4.4	24,800	51,800	24	33
1965	26.6	8.8	3.5	113,300	232,750	28	52
1966	26.3	9.0	4.1	61,000	147,400	26	53

Table IV-A
Sewage Treatment Plant Operating Records for 1966 in the
Washington, D.C. Metropolitan Area

Month	Flow MGD	Suspended Solids			Arlington, Virginia		
		Influent lb/day	Effluent lb/day	Efficiency %	Influent lb/day	Effluent lb/day	Efficiency %
December 1965	14.7	42,508	15,558	63.4	35,158	21,928	37.8
January 1966	15.3	44,115	15,428	64.9	39,780	25,372	36.0
February	19.4	45,267	17,783	60.7	45,913	32,333	30.0
March	17.1	43,605	17,242	60.5	46,882	33,488	29.0
April	17.8	51,768	18,690	63.8	44,055	29,963	32.3
May	18.2	53,842	18,048	66.2	42,467	27,300	35.8
June	17.6	44,880	16,133	64.4	36,080	23,907	33.7
July	17.2	46,440	15,767	66.1	38,557	24,080	37.6
August	16.8	45,360	15,400	66.1	36,120	21,420	40.7
September	17.4	46,110	16,385	64.6	31,465	19,430	38.3
October	17.7	43,808	15,782	64.0	31,565	19,470	38.6
November	16.2	49,815	16,605	66.7	34,965	19,845	43.2
Average for year	17.1	46,460	15,568	64.3	38,500	24,878	35.4

Table IV-A (Cont.)
Sewage Treatment Plant Operating Records for 1966 in the
Washington, D.C. Metropolitan Area

Month	Flow MGD	Suspended Solids			D.C. Water Pollution Control Plant		
		Influent lb/day	Effluent lb/day	Efficiency %	Influent lb/day	Effluent lb/day	Efficiency %
January	191.5	204,267	156,392	23.4	244,162	154,796	36.6
February	215.4	224,375	165,140	26.4	253,095	218,990	13.5
March	201.0	216,075	97,150	55.0	252,925	95,475	62.2
April	214.1	276,546	114,187	58.7	262,272	110,618	57.8
May	222.5	222,500	81,583	63.3	254,021	94,562	62.8
June	231.4	250,633	75,205	70.0	273,823	102,202	62.7
July	232.9	232,900	60,166	74.2	223,196	133,918	40.0
August	233.1	238,928	112,665	52.8	250,582	108,780	56.6
September	231.9	260,888	65,705	74.8	262,820	67,638	74.3
October	216.0	257,400	66,600	74.1	262,800	72,000	72.6
November	206.5	246,079	72,275	70.6	270,171	73,996	72.6
December	209.2	226,633	73,220	67.7	244,067	90,653	62.8
Average for year	217.1	238,106	95,024	60.1	254,494	110,302	56.6

Table IV-A (Cont.)
Sewage Treatment Plant Operating Records for 1966 in the
Washington, D.C. Metropolitan Area

Month	Flow MGD	Alexandria, Virginia					
		Suspended Solids			5-day BOD		
		Influent lb/day	Effluent lb/day	Efficiency %	Influent lb/day	Effluent lb/day	Efficiency %
November 1965	12.0	27,940	5,470	80.4	21,500	4,680	78.2
December	12.3	35,110	6,340	82.0	29,630	6,260	78.9
January 1966	12.8	30,680	6,060	80.3	24,860	5,190	79.1
February	16.9	28,610	9,060	68.3	25,830	7,820	69.7
March	15.8	27,650	8,270	70.0	25,370	8,170	67.8
April	16.9	28,830	7,810	72.9	24,060	7,060	70.7
May	17.9	29,380	7,060	76.0	26,240	6,630	74.8
June	-	-	-	-	-	-	-
July	14.1	28,100	4,380	84.4	20,290	4,120	79.7
August	13.7	29,730	4,680	84.3	21,580	4,030	81.3
September	16.8	44,600	6,990	84.3	24,210	5,100	78.9
October	18.1	29,300	5,830	80.1	22,570	5,100	77.4
Average for year	15.2	30,903	6,541	78.4	24,194	5,833	76.0

Table IV-A (Cont.)

Sewage Treatment Plant Operating Record for 1966 in the

Washington, D.C. Metropolitan Area

Fairfax County, Virginia -- Westgate Plant							
Month	Flow MGD	Suspended Solids			5-day BOD		
		Influent lb/day	Effluent lb/day	Efficiency %	Influent lb/day	Effluent lb/day	Efficiency %
December 1965	9.8	21,245	9,560	55.0	24,094	12,288	49.0
January 1966	10.1	18,297	9,331	49.0	20,236	10,118	50.0
February	12.0	15,844	7,764	51.0	18,036	9,198	49.0
March	12.0	14,618	4,960	66.1	18,923	9,461	50.0
April	10.5	21,007	7,773	63.0	21,886	11,162	49.0
May	10.7	17,833	6,063	66.0	18,189	9,276	49.0
June	9.8	19,144	6,509	66.0	19,144	9,572	50.0
July	9.3	16,987	5,945	65.0	18,509	9,440	49.0 ^a
August	8.8	22,392	7,837	65.0	17,430	9,248	47.0
September	9.6	24,624	9,850	60.0	35,495	17,747	50.0
October	-	-	-	-	-	-	-
November	9.7	18,830	8,097	57.0	21,739	10,435	52.0
Average for year	10.2	19,166	7,608	60.3	21,244	10,722	49.5

THE POTOMAC RIVER ESTUARY MATHEMATICAL MODEL

The Potomac Estuary Mathematical Model was used to develop the dissolved oxygen and total phosphorus profile estimations shown in this report. The model, originally developed by the Delaware Estuary Comprehensive Project for the Delaware Estuary, was later adapted to the Potomac River Estuary by the Chesapeake Bay-Susquehanna River Project, FWPCA.

The computational procedure used in the model is based on the principles of systems analysis. The basic equation on which the model functions is that developed by Dr. D.J. O'Connor¹ for the case of a one-dimensional estuary.

To apply the model, the upper Potomac Estuary was divided into 21 segments of varying lengths and dimensions. Each segment was considered to have constant physical characteristics such as cross-sectional area, volume, and reaction coefficients. The various discharges of a waste constituent into each segment are measured or estimated and a final equation for the segment developed. When this procedure is completed, a series of equations

result. For the Potomac Estuary, this consists of 21 equations with 21 unknowns, the unknowns being the concentration of the constituent sought. A high speed digital computer solves this series of equations and yields the average concentration in each segment. The final profile of the average constituent concentration can then be estimated by fitting a smooth curve through the consecutive segments.

It is to be emphasized that only average concentrations are estimated. The to-and-fro oscillations caused by tidal movement can cause significant variations from the mean value estimated. In fact, on the Potomac Estuary the dissolved oxygen has varied in the past in the order of $\pm 1-2$ mg/l.

Further information on this model can be obtained from the Chesapeake Bay-Susquehanna River Project.

(1) "Oxygen Balance of an Estuary," by D. J. O'Connor, *Transactions, ASCE*, Vol. 86, 1960.

*INTERDEPARTMENTAL TASK FORCE ON THE POTOMAC
REPORT OF THE SUB-TASK FORCE ON SEDIMENTATION & EROSION MAY 1967*

Conclusions and Summary of Recommendations

Land erosion and resulting stream pollution from sedimentation are among factors that recently focused national attention on the Potomac River Basin. Because of concern over this source of pollution, the Interdepartmental Task Force on the Potomac established the Sub Task Force on Sedimentation and Erosion. Accordingly, a working body representing a wide range of Federal, State, and local interests throughout the basin was established. This group was asked to examine in detail soil losses and stream sedimentation rates in the basin and to draw on appropriate principles of resource management for the development of a program to alleviate the erosion and sediment problem. This report describes erosion and sedimentation in the basin, weighs the relative significance of the various sources and proposes a 10-year program for dealing with the overall problem.

Although the Sub-Task Force recognizes that a basin-wide program is the most effective means of controlling the erosion and sediment problem in this report, it also identifies accelerated erosion resulting from urban development, highway construction, and strip mining as distinctive and concentrated sources of sediment which justify early corrective attention. As a result, nearly one-third of the recommended program deals with proposed support measures for controlling these more acute erosion and subsequent sedimentation problems. The Sub-Task Force particularly endorses continued development of new control techniques to deal effectively with these problems. The Sub-Task Force recommends the following measures to accelerate sediment and erosion control in the basin, without reference to priorities:

1. Initiate planning for additional small watershed programs throughout the Potomac Basin.
2. Control of erosion and sedimentation during highway and road construction.
3. Stabilization of road banks along secondary roads.
4. Completion and publication of soil surveys throughout the basin.
5. Economic evaluation of measures and facilitating techniques during the program installation period.

6. Physical evaluation and research of sedimentation and erosion control to provide guidelines for river basin developments in other areas.

7. Augmentation of technical assistance programs for establishment of conservation measures on cropland.

8. Expansion of the cost-sharing program to provide financial assistance for cropland conservation measures.

9. Sediment detention basins in rural areas below critical sediment sources.

10. Expanded technical assistance programs for establishment of conservation measures on pasture land.

11. Expansion of the cost-sharing program to provide added financial assistance for pasture conservation measures.

12. Expansion of the cost-sharing program to provide added financial assistance for forest conservation measures on privately owned land.

13. Acceleration of cooperative Federal-State forestry programs.

14. Increased funding of the "Development Program for the National Forests" within the basin.

15. Expansion of forest research programs relating to erosion control and the reduction of sediment.

16. Expansion of the program to provide technical assistance for erosion and sediment control practices in urban areas.

17. Demonstrations of erosion and sediment control measures in developing urban areas.

18. Sediment detention basins below critical sediment sources in urban and suburban areas.

19. Reclamation of areas damaged by strip mining.

It is the opinion of the Sub-Task Force that the successful completion of the program it proposes will effect a reduction in soil erosion in the basin and the resultant sediment contribution to the Potomac Estuary of about 48 percent.

The cost of the program is estimated at \$250,233,000 with the Federal Government providing \$201,384,000. This cost is for the acceleration of sediment and erosion control measures and is additional to present program levels.

G. W. Cook

U. S. DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION
CONTROL ADMINISTRATION
MID-ATLANTIC REGION

SANITARY BACTERIOLOGY
OF THE
UPPER POTOMAC ESTUARY

by

Donald W. Lear, Jr.

and

Norbert A. Jaworski

March 1969

PENNSYLVANIA

MARYLAND

DISTRICT OF COLUMBIA

VIRGINIA

NORTH CAROLINA

SOUTH CAROLINA

G. W. Cook

Chesapeake Technical Support Laboratory
Middle Atlantic Region
Federal Water Pollution Control Administration
U.S. Department of the Interior

Technical Report No. 6

SANITARY BACTERIOLOGY
OF THE
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INTRODUCTION

As part of the Chesapeake Bay-Susquehanna River Basins Project, the Chesapeake Field Station undertook extensive field investigations to determine the water quality in the Potomac River Basin. A significant part of these studies was the determination of the bacteriological water quality condition of the upper Potomac Estuary.

A study was initiated in winter 1967 to:

1. Determine the bacteriological water quality of the upper Potomac Estuary;
2. Relate bacterial distributions to other water quality parameters;
3. Evaluate an isolation procedure for Salmonellae;
4. Relate the comparative usefulness of coliforms, fecal coliforms, fecal streptococci and Salmonellae as water quality indicators;
5. Identify probable sources of bacterial pollution in the area.

The study area encompassed a reach of

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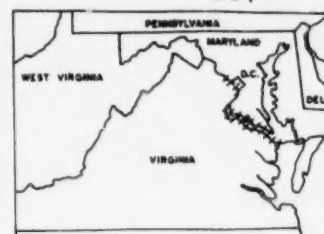
the estuary above the wastewater discharge in the Washington, D. C., metropolitan area to the oyster producing waters of the middle estuary below the Potomac River Bridge at Dahlgren, Virginia. (Figure 1)

STUDY PROCEDURES

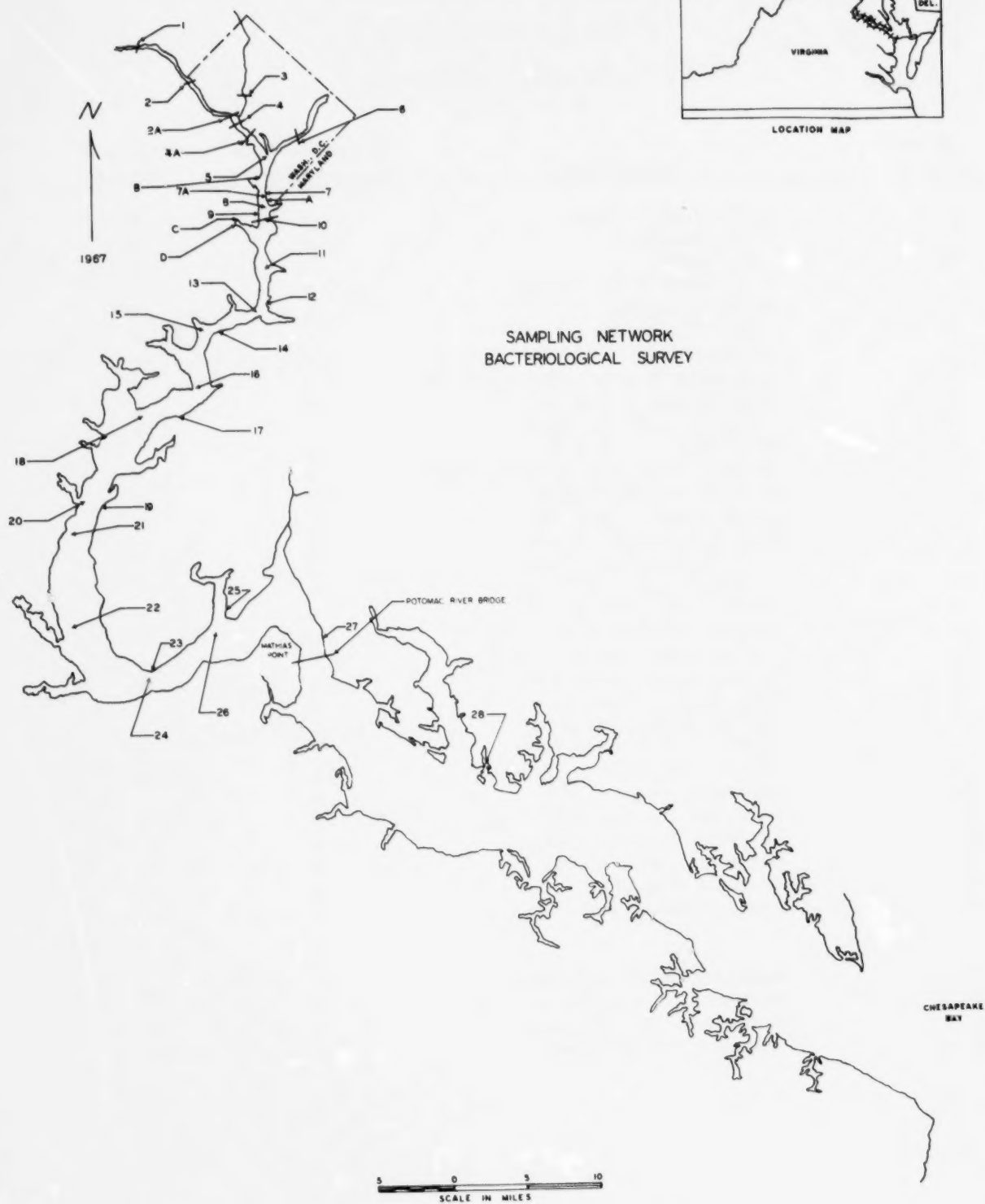
Sampling Stations and Programs

A sampling network of 31 stations was established along 60 miles of the upper Potomac Estuary. Wastewater effluent samples were also obtained from the four major sewage treatment plants in the Washington metropolitan area. Figure 1 and Table 1 give detailed locations of the sampling stations and sewage treatment facilities.

Upstream bacteriological samples above navigable waters in the Washington area were taken from bridges, iced, and returned within three hours to the laboratory at Annapolis for inoculation and incubation. For the remaining estuary studies bacteriological samples were taken to the Chesapeake Field Station mobile camper laboratory located along the river in positions to receive



LOCATION MAP



POTOMAC ESTUARY

FIGURE 1

TABLE 1

Description of Sampling Network

Bacteriological Survey

Chesapeake Field Station

1967

Station No.	Description	Salmonella Samples	Coliform Samples
1	Cabin John Bridge	x	x
2	Chain Bridge	x	x
2A	Key Bridge		x
3	Rock Creek-M St. Bridge	x	x
4	Memorial Bridge	x	x
4A	14th St. Bridge		x
5	Haines Point	x	x
6	Anacostia River-S.Capitol St.Br.	x	x
7	Bolling AFB - Buoy 9	x	x
7A	Bellvue - 23 ft. bell		x
8	Blue Plains - Buoy 8	x	
9	Alexandria Marine Service Dock	x	
10	Woodrow Wilson Bridge	x	x
11	Broad Creek - Buoy 86	x	x
12	Fort Washington - Bank	x	
13	Fort Washington - Buoy 75	x	x
14	Marshall Hall - Dock	x	
15	Dogue Creek - Buoy 67	x	x
16	Hallowing Point - Buoy 61	x	x
17	Indian Head - Navy Dock	x	
18	Indian Head - Buoy 54	x	x
19	Moss Point - Bank	x	
20	Possum Point - Buoy 44	x	x
21	Sandy Point - Buoy 40	x	x
22	Smith Point - Buoy 30	x	x
23	Maryland Point - Bank	x	
24	Maryland Point - Buoy 19-21	x	x
25	Nanjemoy Creek - Dock	x	
26	Nanjemoy Creek - Buoy 11	x	x
27	Aqualand Seawall	x	
28	Cobb Island - Bank	x	
A	Blue Plains STP effluent	x	x
B	Arlington STP effluent	x	x
C	Alexandria STP effluent	x	x
D	Westgate STP effluent	x	x

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samples directly from boat crews. Water samples were immediately inoculated into presumptive media and incubated aboard the camper. This procedure was instituted to minimize any bacteriological changes during the transport period.

Salmonellae were isolated by an immersed swab procedure (1). Bundles of cheesecloth strips (swabs) were suspended from bridges or buoys at various points in the river. Where the swabs could not be suspended in midwater due to inaccessibility, they were tied to stakes near shore in one foot lengths of four inch PVC pipe to minimize contact with bottom sediments. The swabs were usually immersed for a period of five days; however, at times the duration ranged from four to seven days because of weather conditions controlling the installation and retrieval.

Disposable polyethylene gloves were used in the handling of swabs during retrieval. The swabs were placed in polyethylene bags, tightly secured, and iced for return to the laboratory at Annapolis for further processing. No attempt was made to pre-sterilize the swabs, gloves, or polyethylene bags. Control swabs, identical in handling except for immersion, were run in

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parallel and yielded uniformly negative results.

A departure from the swab technique was made for the isolation of Salmonellae from sewage treatment plant effluents. For the effluents, 150 ml of sample was passed through HA millipore filters*, with the filters processed similarly to the retrieved swabs.

Analytical Procedures

1. Indicator Bacteria (Coliform, Fecal Coliform and Fecal Streptococci)

The 5-tube dilution MPN technique was used. For presumptive coliforms and fecal coliforms Difco lauryl tryptose broth was employed; for presumptive fecal streptococci Difco azide dextrose broth was used. Incubation was at 35°C.

Coliforms were confirmed in Difco brilliant green bile 2% broth. Fecal streptococci were confirmed in Bacto ethyl violet azide broth. Fecal

* HA millipore filter has an effective pore size of 0.45 microns

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coliforms were confirmed in Bacto EC medium, incubated at 45.5°C. These procedures are outlined in detail in Standard Methods (2).

2. Salmonella

In the laboratory each swab was cut with alcohol-flamed scissors and approximately one-third of each swab was placed in 300 ml of tetrathionate enrichment broth. This was incubated at 40.5°C for twenty-four hours in a water-jacketed incubator. Subsequently, a sterile bacteriological loop was used to streak from the enrichment medium onto brilliant green agar plates and, in parallel, on SBG agar plates. These latter plates were abandoned after the first few attempts as this method did not yield enough presumptive *Salmonella* colonies to warrant further use in this study.

The brilliant green or the SBG agar plates were incubated at 40.5°C overnight and characteristic presumptive *Salmonella* colonies were fished with a sterile bacteriological needle and placed in parallel on triple sugar iron (TSI) agar slant stabs, motility sulfide (MS) agar stabs and inoculated into "H broth."

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The TSI slants were read between eight and eighteen hours. It was found that leaving this medium overnight resulted in a masking of the color reactions by excessive sulfide production; consequently shorter reading intervals were used. After noting slant, butt and sulfide reactions in the TSI tubes, a loopful of culture from the slant was used for a slide agglutination test with polyvalent Salmonella "O" antiserum.

In the motility and sulfide medium, reaction for motility and sulfide was first noted, then the tubes flooded with buffered urea solution, incubated at 35°C for six hours to note the presence or absence of urease production. A portion of the culture in "H broth" was used to test for the presence or absence of indol. A further aliquot of "H broth" was used for a tube agglutination test with polyvalent Salmonella "H" antiserum.

After initially screening all cultures with this procedure, cultures were again purified on brilliant green agar and again subjected to this series of tests. Forty-one selected cultures isolated from the upper Potomac Estuary were sent to the U. S. Public Health Service Communicable Disease Center at Atlanta,

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Georgia, for further diagnosis to species serologically.

Details of the Salmonella isolation scheme are elaborated by Sino (1). Strict adherence to details outlined by Spino is recommended, for this scheme is extremely empirical and small deviations can result in failure.

CLIMATOLOGICAL CONDITIONS

During the months of January and February 1967, the weather was generally cold and dry with the Potomac River discharge at approximately 10,000 cfs. A light rainstorm with above-freezing temperatures covered much of the Potomac watershed during the period from March 4 through 7. The rainstorm and thaw increased the runoff to a maximum discharge of 140,000 cfs on March 9, 1967. (See Figure 2)

The average climatological conditions for the three months of the study are given below.

<u>Parameter</u>	<u>January</u>	<u>February</u>	<u>March</u>
Air temperature (Deg. F ^o)	41.0	34.0	45.0
Water temperature (Deg. F ^o)	37.0	37.8	42.7
River discharge (cfs)	9,700	10,800	35,600
Precipitation (inches)	1.35	2.32	3.49

POTOMAC RIVER FLOW at GREAT FALLS
BACTERIOLOGICAL SURVEY

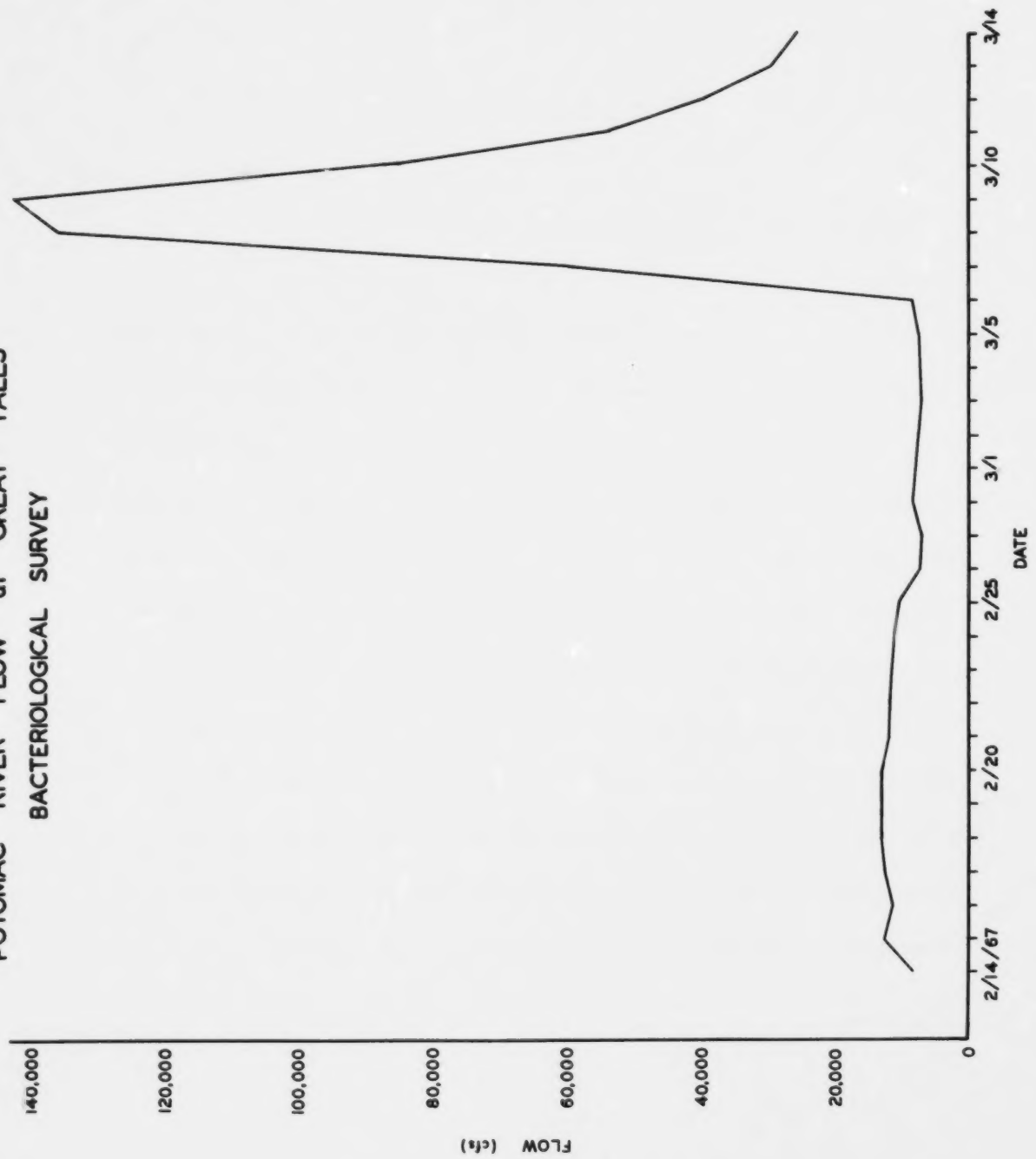


FIGURE 2

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RESULTS OF STUDY

Sources of Coliform Organisms

Three major sources of coliform organisms in the upper estuary were: (1) wastewater discharges, (2) storm and combined sewers, and (3) fresh water inflows. Using the data for the sewage treatment effluents for the major discharges and fresh water inflow, an estimate of the coliform organism loadings for the months of February 1967 was determined and is presented below.

As can be seen in the tabulation, the contribution of coliform organisms from wastewater effluents is more than 100-fold greater than from the fresh water inflow from the upper basin. No estimate was made of storm or combined sewer contributions.

	Coliform (MPN/day)	Fecal Coliform (MPN/day)	Fecal Strep. (MPN/day)
Fresh water inflow*	0.12×10^{15}	0.04×10^{15}	0.08×10^{14}
Wastewater treatment discharge**	160.0×10^{15}	19.5×10^{15}	60.3×10^{14}

* Based on an average flow for the month of February 1967 of 10,800 cfs.

** Based on the bacterial densities for Blue Plains, Arlington and Alexandria data as presented in Table 2.

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Estuarine Water Quality Conditions

Figure 3 is an isopleth plot* of coliform distribution in the study area. The region of greatest coliform density ($> 100,000$ MPN/100 ml), with steady flow conditions of approximately 10,000 cfs, seemed to equilibrate in the reach from just below the District of Columbia downstream to Hallowing Point, approximately 15 miles of estuary. The sudden rise in fresh water flows carried these high coliform densities, with some small contribution from local land runoff as evidenced by the increased count at Chain Bridge, downstream at least 40 miles, the lower limit of this study.

*An isopleth is made by plotting coliform densities as a function of time and distance, and connecting equal values. The response of the estuary to the coliform loadings can be seen at a given time by following distributions from a fixed point in time down the horizontal axis, representing the reach of estuary studied. Conversely, at a fixed point in the estuary, the changes of the densities with time can be seen by reading up a vertical axis from a designated location.

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This investigation did not include the estuary below Mathias Point which is the upper limit of the oyster harvesting areas. These waters would probably be affected by the increased flows which transport the indicator organisms apparently originating in the metropolitan area.

The fecal coliform densities (Figure 4) showed a similar response to the high flow conditions, but a bacterial density approximately one decimal order of magnitude lower than coliforms. The reach of the estuary affected was identical.

Figure 5 presents the distribution of fecal streptococci in the upper Potomac Estuary. Distribution patterns were similar to those for coliforms and fecal coliforms, but the area of high bacterial density was not as extensive, consonant with the concept that fecal streptococci have a relatively faster die-off rate in water than coliforms or fecal coliforms and are indicators of recent pollution. (3)

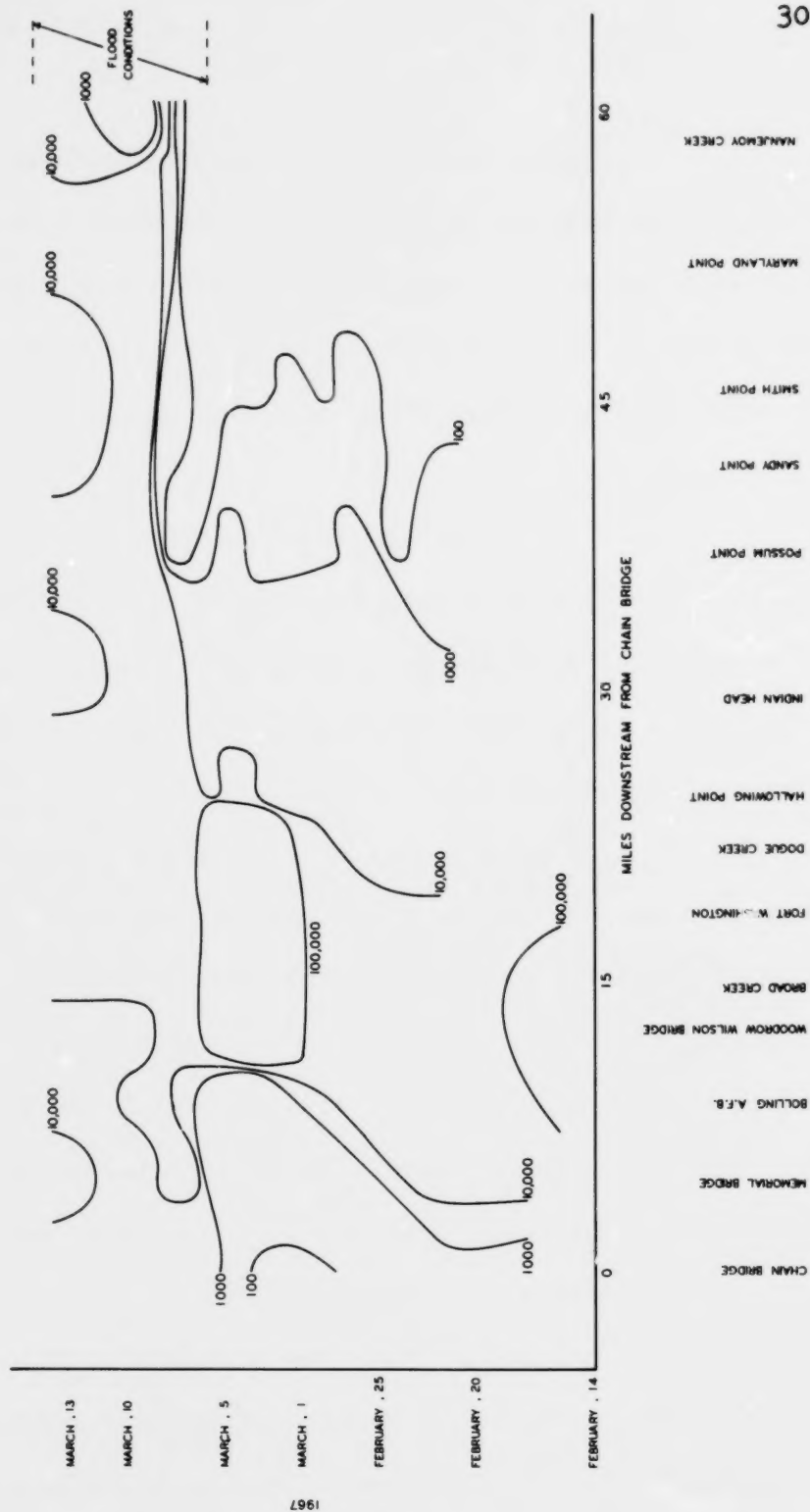
Figure 6 shows the exposure of *Salmonella* swabs and subsequent recovery or lack of recovery of *Salmonella* isolates. The area of greatest incidence included the metropolitan area downstream to Indian Head,

COLIFORM DISTRIBUTION ISOPLETH

(mpn/100 ml)

UPPER POTOMAC ESTUARY

CHESAPEAKE TECHNICAL SUPPORT LABORATORY



FECAL COLIFORM DISTRIBUTION ISOPLETH

(mpn/100 ml)

UPPER POTOMAC ESTUARY

CHESAPEAKE TECHNICAL SUPPORT LABORATORY

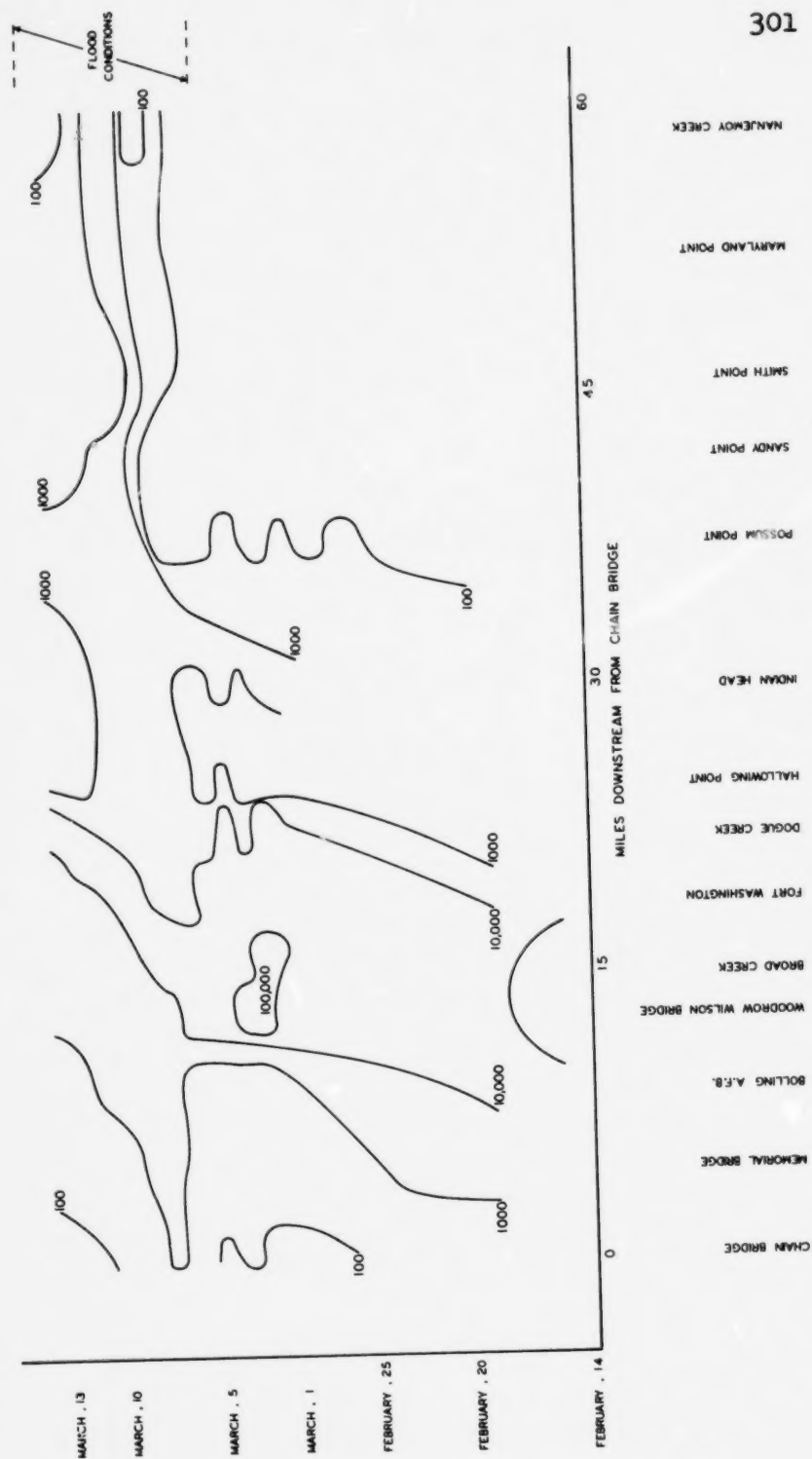


FIGURE 4

FECAL STREPTOCOCCI ISOPLETH

(mpn/100 ml)

UPPER POTOMAC ESTUARY

CHESAPEAKE TECHNICAL SUPPORT LABORATORY

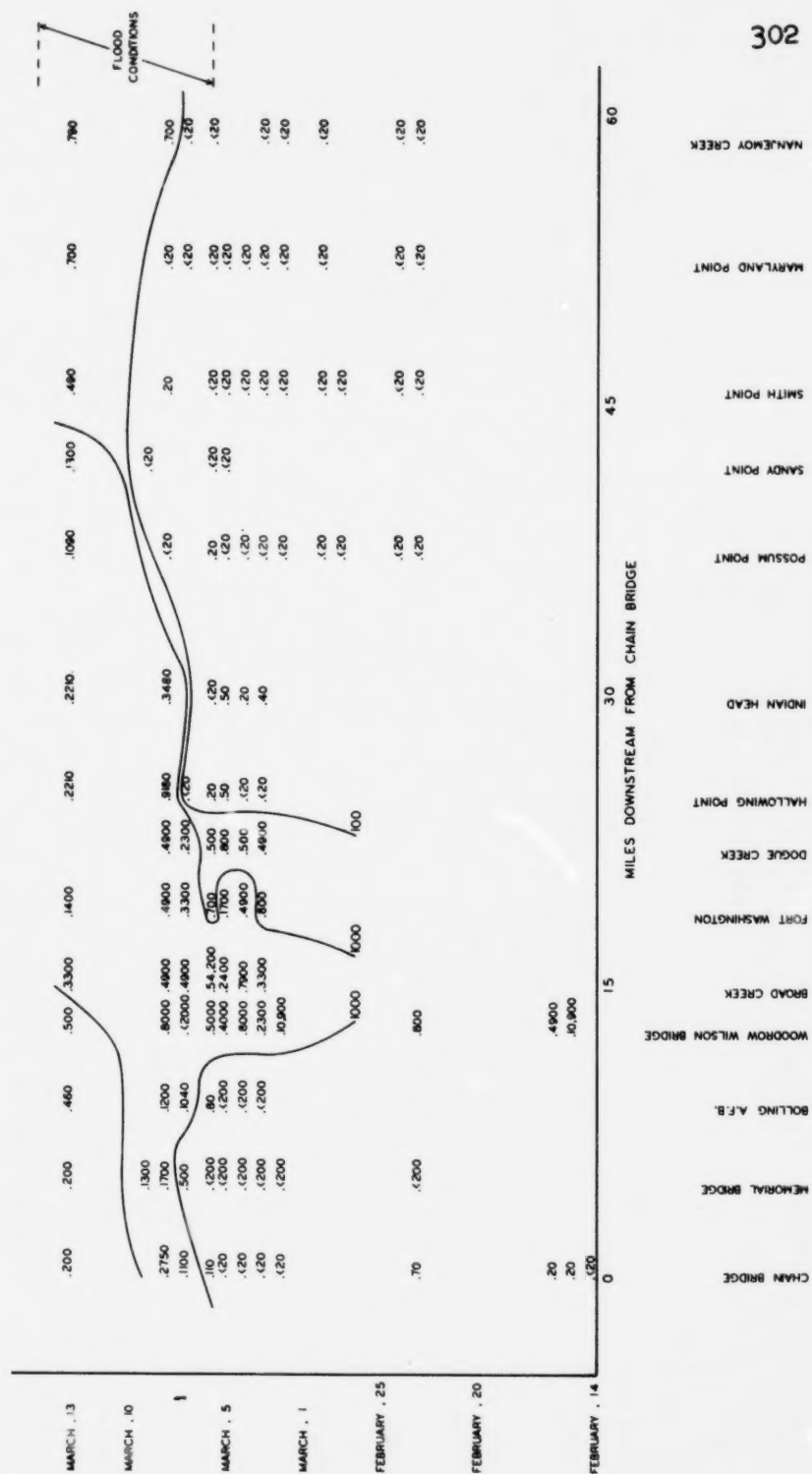


FIGURE 5

SALMONELLA RECOVERY
UPPER POTOMAC ESTUARY
CHESAPEAKE TECHNICAL SUPPORT LABORATORY

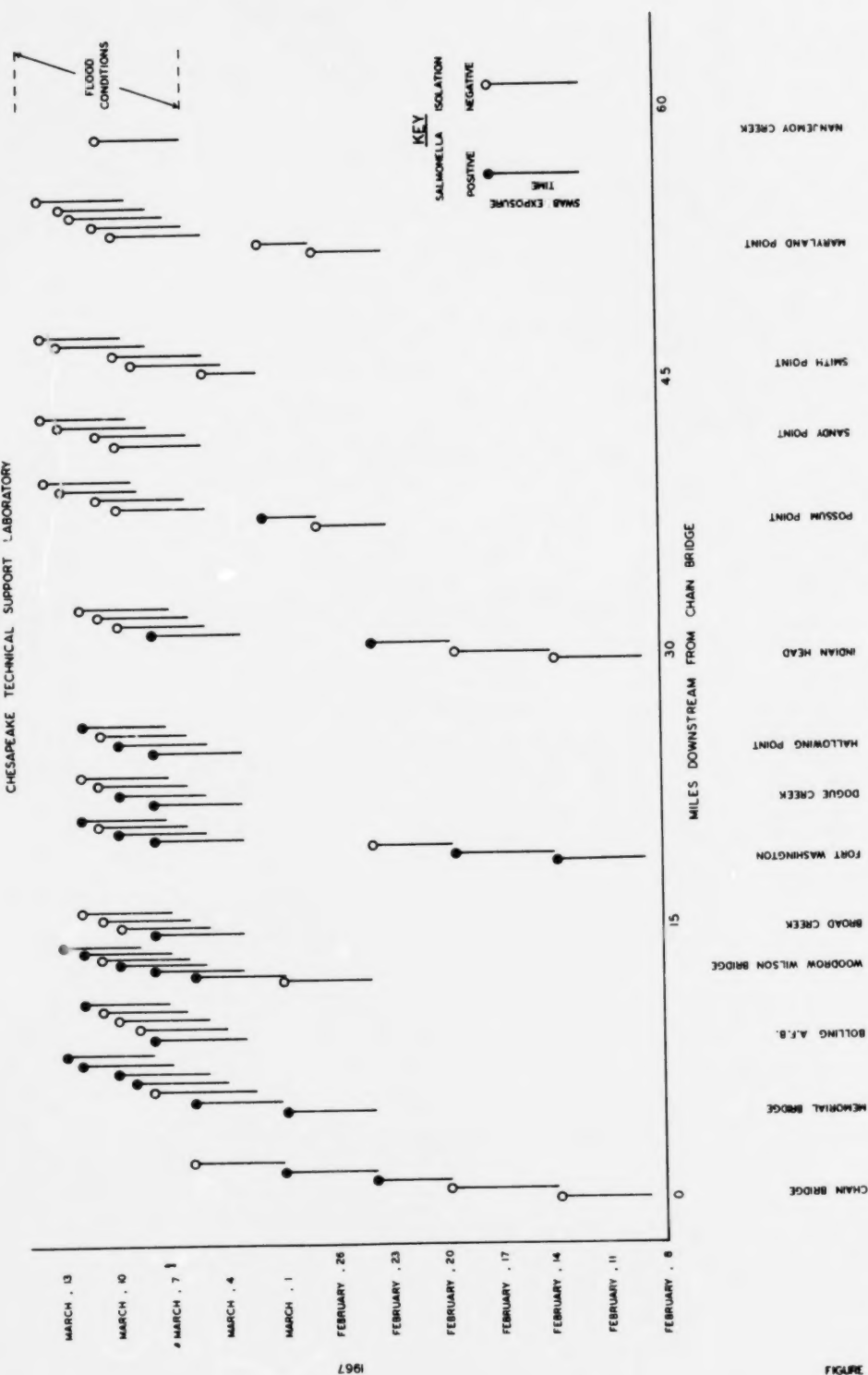


FIGURE 9

TABLE 2
SALMONELLAE AND INDICATOR-BACTERIAL DATA
UPPER POTOMAC ESTUARY
JANUARY - MARCH 1967
CHESAPEAKE TECHNICAL SUPPORT LABORATORY

Date Swab Set	Date Swab Retrieved	Date Sample Taken	Time Sample Taken	Water Temp °C	Coliform MPN/100 ml	Fecal Coliform MPN/100 ml	Streptococci MPN/100 ml	Salmonella Recovery	Salmonella Serotype
Station 1 - Cabin John Bridge									
1-20	1-24	1-31	1545	4	13,000	1,100	100	-	
		2-06			2,100	490	< 20		
		2-14	1030		50	20	< 20		
		2-20	1045		790	230	20		
Station 2 - Chain Bridge									
2-09	2-14	1-31	1450	4	9,180	1,300	80		
		2-06			790	130	< 20		
		2-14	1100		130	< 20	< 20		
		2-15	1130	4.5	330	170	20		
		2-16	1040	5.5	230	230	20		
2-14	2-20	2-23	1100		790	170	70		
2-20	2-24	3-02	0945	0	80	50	< 20		
-	3-01	3-03	1015	3	90	20	< 20	+	S. typhimurium
		3-04			310	230	< 20	+	S. montevideo
		3-05			330	50	< 20		
	3-06	3-06	0930	5	3,480	790	110		
		3-07	0920		9,180	790	1,100		
		3-08	0940	4.8	6,300	2,400	2,780		
		3-09	0930	5	3,480	130			
		3-10	1220	7		1,090			
		3-11							
		3-12	0915	7					
		3-13	1000	8	1,200	80	200		
Key Bridge - 3.3 miles from Station 2									
1-24		0810			200	< 200	< 200		
1-30		1555		4	16,090	3,480	490		
2-15		1155		4.5	1,300	490	20		
2-16		1025		5	2,400	1,300	50		

TABLE 2 - continued

Date Swab Set	Date Swab Retrieved	Date Sample Taken	Time Sample Taken	Water Temp °C	Coliform MPN/100 ml	Fecal Coliform MPN/100 ml	Streptococci MPN/100 ml	Salmonella Recovery	Salmonella Serotype
<u>Station 3 - Rock Creek, M Street Bridge</u>									
2-14	2-20	2-23	1125		500	500	< 200	+	S. eimsbuettel
2-20	2-24	3-01	1100	0	17,000	3,300	200	+	
-	3-01	3-02	1100	2	1,609,000	3,300	900	+	
		3-03			141,000	14,000	2,000		
		3-04			55,000	5,000	4,000		
		3-05			330,000	26,000	7,000	+	
	3-06	3-06	0950	6	100,000	13,000	70,000		
		3-07	0945	5.5	23,000	23,000	2,000		
		3-08	1020	3.5	13,000	5,000	< 2,000		
3-05	3-10	3-09	1000	4				+	S. bredeney (027 neg)
		3-10	1150	6					
		3-11		8					
3-08	3-13	3-12	0945	6.5	11,000	< 2,000	23,000	-	
		3-13	1020						
<u>Station 4 - Memorial Bridge</u>									
1-20	1-24	2-23	1125		12,000	9,000	7,900	+	S. cubana
-	3-01	3-01	1100	0	200	< 200	< 200	+	
		3-02	1100	2	500	200	< 200		
		3-03			< 200	< 200	< 200		
		3-04			000	< 200	< 200		
	3-05	3-05	1015	5	500	200	< 200	+	
	3-06	3-06	1600	4	34,500	800	500		
3-03	3-08	3-07	1040	4	24,000	3,300	1,700	-	
3-04	3-09	3-08	1015	5	4,600	1,300	1,300	+	
3-05	3-10	3-10	1120	6		800		+	
3-07	3-12	3-11	1000	8	11,000	400	200	+	S. muenchen
3-08	3-13	3-12	1045	8				+	
<u>14th Street Bridge - 5.7 miles from Station 2</u>									
		1-24	0820		500	200	< 200		
		1-30	1530	3.5	16,090	2,400	700		
		2-15	1050		490	490	40		
		2-16	1005		9,180	2,210	140		
<u>Station 5 - Haines Point, Buoy 2</u>									
1-11	1-12	1-24	0830		< 200	< 200	< 200	+	S. thompson
1-11	1-16	1-30	1515	4	34,800	2,400	3,480	-	

TABLE 2 - continued

Date Swab Set	Date Swab Retrieved	Date Sample Taken	Time Sample Taken	Water Temp °C	Coliform MPN/100 ml	Fecal Coliform MPN/100 ml	Fecal Streptococci MPN/100 ml	Salmonella Recovery	Salmonella Serotype
<u>Station 6 - Anacostia River, Sousa Bridge</u>									
-	3-01	2-23	1400		34,800	5,420		-	
		3-01							
		3-02	1330	3	4,900	2,300	< 200		
		3-03	1230	5	4,900	2,200	< 200		
		3-04			7,900	800	< 200		
		3-05			7,000	2,300	200		
		3-06	1200	8	160,900	54,200	17,200		
		3-07	1100	4.5	221,000	70,000	9,000		
3-03	3-08	3-08	1320	6	160,900	54,200	4,600	+	S. typhimurium var. copenhagen
		3-09	1215	6	34,800	2,200			
		3-10	1045	7					
3-06	3-11	3-11	1130	9				-	
3-07	3-12	3-12	1240	9.5	24,000	1,100	500	+	
3-08	3-13	3-13						+	
<u>Station 7 - Bolling Air Force Base, Buoy 9</u>									
		3-03	1010	2	800	270	< 200		
		3-04	1015	2	800	< 200	< 200		
		3-05	1005	4	800	800	< 200		
		3-06	1010	4.5	700	130	80		
		3-07	1025	4.5	5,420	790	1,090		
3-03	3-08	3-08	0945	3.5	34,800	4,600	1,200	+	
3-04	3-09	3-09	1020	5	10,900	3,480		-	
3-05	3-10	3-10	0945	5.5		1,720		-	
3-06	3-11	3-11						-	
3-07	3-12	3-12						-	
		3-13						+	S. heidelberg
<u>Bellevue - "Fld" 23 Bell - 9.9 miles from Station 2</u>									
		1-24	0840		70,000	31,000	200		
		1-30	1500	4	24,000	4,900	4,900		
		1-31	1325	5	240,000	79,000	2,300		
<u>Station 8 - Blue Plains, Buoy 8</u>									
1-11	1-12							+	S. newport
1-11	1-16							+	S. typhimurium var. copenhagen
1-20	1-24							+	S. derby
								+	S. infantis

TABLE 2 - continued

Date Swab Set	Date Swab Retrieved	Date Sample Taken	Time Sample Taken	Water Temp °C	Coliform MPN/100 ml	Fecal Coliform MPN/100 ml	Fecal Streptococci MPN/100 ml	Salmonella Recovery	Salmonella Serotype
<u>Station 10 - Woodrow Wilson Bridge</u>									
1-11	1-16	1-24	0850	4.5	34,800	17,200	500	+	S. typhimurium var. copenhagen
		1-30	1145	5	91,800	34,800	7,600	+	S. montevideo
		1-31	1305		24,000	13,000	800		
		2-15	1015		1,609,000	220,000	10,900		
		2-16	0940		210,000	141,000	4,900		
		2-23	1300		31,000	11,000	800		
-	3-01	3-02	1215	2	175,000	94,000	10,900	-	
		3-03	1145	3	1,609,000	1,609,000	2,300		
		3-04			320,000	240,000	8,000		
		3-05			141,000	79,200	4,000		
	3-06	3-06	1050	5	260,000	34,000	5,000	+	S. albari
		3-07	1035	4.5	58,000	11,000	< 2,000	+	
		3-08	1130	5	13,000	< 2,000	8,000	+	
3-03	3-08	3-09	1130	6	7,000	2,000		+	
3-04	3-09	3-10	1000			2,300		+	
3-05	3-10	3-11	1045	8	8,200	1,100	500	-	S. manhattan
3-06	3-11	3-12	1130	8.5				+	
3-07	3-12	3-13						+	
3-08	3-13							+	
<u>Station 11 - Broad Creek, Buoy 86</u>									
		1-24	0905	5	13,000	4,900	700		
		1-31	1250		49,000	14,000	800		
		3-03	1100	3	542,000	172,000	3,300		
		3-04	1040	3	542,000	31,000	7,900		
		3-05	1030	4	91,800	91,800	2,400		
		3-06	1045	4.5	210,000	91,800	54,200		
		3-07	1110	4.5	34,800	13,000	4,900	+	S. montevideo
3-03	3-08	3-07	1020	4	54,200	24,000	4,900	-	
3-05	3-10	3-10	1010	5.5		4,900		-	
3-06	3-11	3-11						-	
3-07	3-12	3-12						-	
		3-13			34,800	7,900	3,300		
<u>Piscataway Creek Fl - 18.2 miles from Station 2</u>									
		1-24	0920	5	3,300	2,300	< 200		
		1-31	1225		24,000	3,300	500		
<u>Station 12 - Fort Washington bank</u>									
1-26	1-31	1-31						+	S. typhimurium
2-09	2-14	2-14						+	S. give
2-14	2-20	2-20						+	
2-20	2-24	2-24						-	

TABLE 2 - continued

Date Swab Set	Date Swab Retrieved	Date Sample Taken	Time Sample Taken	Water Temp °C	Coliform MPN/100 ml	Fecal Coliform MPN/100 ml	Streptococci MPN/100 ml	Salmonella Recovery	Salmonella Serotype
<u>Station 13 - Fort Washington, Buoy 75</u>									
		3-03	1120	3	160,900	34,800	800		
		3-04	1100	3.5	160,900	54,200	4,900		
		3-05	1045	3.5	160,900	54,200	1,700		
		3-06	1105	4.5	240,000	13,000	700		
		3-07	1135	5	34,800	2,300	3,300		
3-03	3-08	3-08	1050	4.5	34,800	4,900	4,900	+	S. bredeney
3-05	3-10	3-10	1030	5.5				+	S. montevideo
3-06	3-11	3-11						-	
3-07	3-12	3-12						+	S. tennessee
		3-13			63,000	2,500	1,400		
<u>Station 14 - Marshall Hall dock</u>									
1-26	1-31							-	
2-09	2-14							+	S. montevideo
2-14	2-20							-	
<u>Station 15 - Dogue Creek, Buoy 67</u>									
		1-24	0935		3,300	800	< 200		
		1-31	1145	5	13,000	1,300	200		
		3-03	1140	3	160,900	54,200	4,900		
		3-04	1110	3	160,900	7,000	500		
		3-05	1100	3.5	54,200	24,000	800		
		3-06	1120	4.5	160,900	4,900	500		
		3-07	1205	5	24,000	3,300	2,300		
3-03	3-08	3-08	1110	3.8	91,800	1,700	4,900	+	S. eimsbuettel
3-05	3-10	3-10	1050	7		7,000		+	S. montevideo
3-06	3-11	3-11						-	
3-07	3-12	3-12						-	
<u>Station 16 - Hallowing Point, Buoy 61</u>									
		1-24	0950		63,000	11,000	900		
		1-31	1120	5	1,300	500	< 200		
		3-03	1205	3	3,480	110	< 20		
		3-04	1130	3	16,090	700	< 20		
		3-05	1115	2.5	16,090	5,420	50		
		3-06	1135	4.5	2,400	340	20		
		3-07	1235	5	10,900	5,420	< 20		
3-03	3-08	3-08	1125	4.5	34,800	7,000	9,180	+	S. give
3-05	3-10	3-10	1115			3,480		+	S. newport
3-06	3-11	3-11						-	
3-07	3-12	3-12						+	S. heidelberg
		3-13			34,000	170	790		

TABLE 2 - continued

Date Swab Set	Date Swab Retrieved	Date Sample Taken	Time Sample Taken	Water Temp °C	Coliform MPN/100 ml	Fecal Coliform MPN/100 ml	Streptococci MPN/100 ml	Salmonella Recovery	Salmonella Serotype
<u>Station 17 - Indian Head dock</u>									
1-20	1-24	1-24	1005					+	S. alachua
1-26	1-31	1-31	1100	5	700	200	< 200	-	
1-31	2-06	2-06	1230	2.5	3,480	110	< 20	+	S. montevideo
2-09	2-14	2-14	1150	3	9,180	2,400	40	-	
2-14	2-20	2-20	1130	2.5	9,180	700	20	-	
2-20	2-24	2-24	1150	4.5	9,180	1,720	50	-	
			1150	4	9,180	210	< 20	-	
3-03	3-06	3-08	1200	6.5	91,800	24,000	3,480	+	S. give
3-05	3-10	3-10	1140			5,420		-	
3-06	3-11	3-11						-	
3-07	3-12	3-12						-	
		3-13			3,480	330	2,210	-	
<u>Station 19 - Moss Point bank</u>									
2-23	2-27	2-27						+	S. senftenberg
	3-02	3-02						+	
<u>Station 20 - Possum Point, Buoy 44</u>									
2-23	2-24	2-24	1300	4	790	70	< 20		
2-24	2-25	2-25	1205	2	20	< 20	< 20		
2-27	2-27	2-27	1150	4	1,090	460	< 20		
2-28	3-02	3-02	1300	3	700	130	< 20		
3-03	3-03	3-03	1235	6	490	< 20	< 20		
3-04	3-05	3-05	1203	4.5			< 20		
3-05	3-05	3-05	1230	3	1,720	170	< 20		
3-06	3-06	3-06	1325	3.5	490	40	< 20		
3-08	3-08	3-08	1230	5	40	< 20	< 20		
3-09	3-09	3-09	1300	5	16,090	2,400	< 20		
3-10	3-10	3-10		6		490			
3-11	3-11	3-11							
3-12	3-12	3-12		7					
3-13	3-13	3-13	1205		16,090	2,400	1,090	-	S. senftenberg
3-05	3-10	3-10						-	
3-06	3-11	3-11						-	
3-08	3-13	3-13						-	
3-09	3-14	3-14						-	

TABLE 2 - continued

Date Swab Set	Date Swab Retrieved	Date Sample Taken	Time Sample Taken	Water Temp °C	Coliform MPN/100 ml	Fecal Coliform MPN/100 ml	Fecal Streptococci MPN/100 ml	Salmonella Recovery	Salmonella Serotype
<u>Station 21 - Sandy Point, Buoy 40</u>									
		3-05	1215	4	130	20	< 20		
		3-06	1245	4	50	< 20	< 20		
		3-08	1200	4	170	20	< 20		
		3-09	1220	5					
3-05		3-10	1125	5.5		1,720		-	
3-06		3-11				9,180		-	
		3-12	1135	6.5				-	
3-08		3-13			5,420	330	1,300	-	
3-09		3-14						-	
<u>Station 22 - Smith Point, Buoy 30</u>									
		2-23	1120	4	80	20	< 20		
		2-24	1105	3	20	< 20	< 20		
		2-27	1100	2	220	< 20	< 20		
		2-28	1230	4	< 20	< 20	< 20		
		3-02	1230	3	110	< 20	< 20		
		3-03	1200	4.5	80	< 20	< 20		
		3-04	1120		20	< 20	< 20		
		3-05	1130	3	< 20	< 20	< 20		
	3-05	3-06	1215	4	50	50	< 20		
		3-08	1145	4	700	230	20		
3-04		3-09	1135	5	16,090	3,480		-	
3-05		3-10	1100	5.5		790		-	
		3-11							
3-08		3-13	1100	6.2					
3-09		3-14			2,400	490	490		
<u>Station 23 - Maryland Point bank</u>									
2-23		2-27							
-		3-02							
<u>Station 24 - Maryland Point, Buoy 19</u>									
		2-23	1045	4	20	< 20	< 20		
		2-24	1035	3	< 20	< 20	< 20		
		2-27	1025	1	20	< 20	< 20		
		3-02	1150	3	< 20	< 20	< 20		
		3-03	1125	4	330	< 20	< 20		
		3-04	1040	5.5	50	< 20	< 20		
		3-05	1045	4	20	< 20	< 20		
		3-06	1140	3.5	< 20	< 20	< 20		
		3-07	1055	4	20	20	< 20		
		3-08	1110	3.5	2,400	330	< 20		
		3-09	1050	5	16,090	490	< 20		
		3-11	1030	5.5		1,300	< 30		
3-05		3-10							
3-06		3-11							
3-07		3-12							
		3-13	1025	6.5	16,090	230	700		

TABLE 2 - continued

Date Swab Set	Date Swab Retrieved	Date Sample Taken	Water Temp °C	Coliform MPN/100 ml	Fecal Coliform MPN/100 ml	Fecal Streptococci MPN/100 ml	Salmonella Recovery	Salmonella Serotype
Station 25 - Nanjemoy Creek dock								
1-26	1-31						-	
1-31	2-06						-	
Station 26 - Nanjemoy Creek, Buoy 11								
		2-23	4	< 20	< 20	< 20		
		2-24	3	< 20	< 20	< 20		
		2-28	4	< 20	< 20	< 20		
		3-02	2	< 20	< 20	< 20		
		3-03	4	< 20	< 20	< 20		
		3-06	3	< 20	< 20	< 20		
		3-07	4	< 20	< 20	< 20		
		3-08	4	20	< 20	< 20		
		3-08	4	16,090	5,420	700		
		3-09	4	230	50			
		3-10	4	2,400	2,400			
3-06	3-11	3-11	5.5		60	790	-	
3-08	3-13	3-13					-	
3-09	3-14	3-14					-	
Station 27 - Aqualand seawall								
1-26	1-31						-	
1-31	2-06						-	
2-09	2-14						-	
2-14	2-20						-	
Station 28 - Cobb Island bank								
2-09	2-14						-	
2-14	2-20						-	
Station A - Blue Plains Sewage Treatment Plant								
		2-02		16,090,000	5,420,000	348,000		
		2-06		16,090,000	5,420,000	172,000		
		2-13		9,180,000	790,000	230,000		
		2-13		17,200,000	700,000	220,000		
	2-13	2-14		5,420,000	700,000	140,000		S. infantis
		2-14		17,200,000	2,300,000	220,000		
		2-14		34,800,000	10,900,000	4,600,000		
		2-15		17,200,000	4,600,000	330,000		
		2-15		54,200,000	1,100,000	330,000		
		2-17		5,420,000	330,000	500,000		
		2-20		17,200,000	1,090,000	260,000		
		2-21		17,200,000	20,000	130,000		
		2-21		5,420,000	40,000	330,000		S. cubana

TABLE 2 - continued

Date Swab Set	Date Swab Retrieved	Date Sample Taken	Time Sample Taken	Water Temp °C	Coliform MPN/100 ml	Fecal Coliform MPN/100 ml	Streptococci MPN/100 ml	Salmonella Recovery	Salmonella Serotype
Station B - Arlington Sewage Treatment Plant									
		2-02	1140		2,400,000	790,000	918,000		
		2-03	1020		3,480,000	1,300,000	330,000		
		2-03	1310		5,420,000	1,300,000	490,000		
		2-09	1340		24,000,000	5,420,000	278,000		
		2-06	1455		16,090,000	16,090,000	542,000		
		2-13	1015		5,420,000	2,400,000	490,000		
	2-13	2-13	1330		2,400,000	2,400,000	140,000	-	
		2-14	1200		3,480,000	700,000	1,090,000		
	2-14	2-14	1415		9,400,000	2,100,000	790,000	+	S. cubana
		2-15	1020		3,480,000	2,400,000	490,000		
		2-15	1310		3,480,000	3,480,000	700,000		
		2-17	1035		2,400,000	490,000	790,000		
		2-17	1300		16,090,000	630,000	500,000		
		2-20	1130		3,480,000	1,090,000	1,400,000		
		2-21	1055		9,180,000	110,000	490,000		
		2-21	1330		24,000,000	210,000	700,000		
Station C - Alexandria Sewage Treatment Plant									
		2-02	1215		5,420,000	490,000	175,000		
		2-03	1050		1,720,000	110,000	330,000		
		2-03	1340		9,180,000	5,420,000	700,000		
		2-06	1410		16,090,000	3,480,000	918,000		
		2-07	1525		17,200,000	2,400,000	542,000		
		2-13	1045		10,900,000	700,000	110,000		
		2-13	1400		16,090,000	1,720,000	130,000	+	S. newington
	2-13	2-14	1230		16,090,000	460,000	80,000		
		2-14	1445		10,900,000	800,000	230,000		
	2-14	2-15	1050		16,090,000	9,180,000	230,000	+	S. muenchen
		2-15	1340		9,180,000	3,480,000	490,000		
		2-17	1105		7,000,000	1,700,000	80,000		
		2-17	1330		5,420,000	330,000	230,000		
		2-20	1200		3,480,000	460,000	1,090,000		
		2-21	1125		5,420,000	50,000	130,000		
		2-21	1400		9,180,000	40,000	490,000		

TABLE 2 - continued

Date Swab Set	Date Swab Retrieved	Date Sample Taken	Time Sample Taken	Water Temp °C	Coliform MPN/100 ml	Fecal Coliform MPN/100 ml	Fecal Streptococci MPN/100 ml	Salmonella Recovery	Salmonella Serotype
					Station D - Fairfax Westgate Sewage Treatment Plant				
					542,000	49,000	110,000		
		2-02	1330		< 2,000	< 2,000	< 2,000		
		2-03	1120		< 2,000	< 2,000	< 2,000		
		2-03	1400		< 20,000	< 20,000	< 20,000		
		2-13	1110		< 20,000	< 20,000	< 20,000	-	
	2-13	2-13	1430		< 20,000	< 20,000	< 20,000		
		2-14	1250		< 20,000	< 20,000	< 20,000		
		2-14	1510		< 20,000	< 20,000	< 20,000		
	2-14	2-14	1115		500	< 200	< 200		
		2-15	1400		< 200	< 200	< 200		
		2-17	1130		330	< 20	< 20		
		2-17	1350		170	50	< 20		
		2-20	2125		790	< 20	< 20		
		2-21	1145		50	< 20	40		
		2-21	1420		20	< 20	50		

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Maryland. Somewhat surprising were the isolations from Chain Bridge, where generally low coliform and fecal coliform densities were found.

DISCUSSION

Indicator Bacteria in the Potomac Estuary

The 14-fold increase in fresh water flow of the Potomac River during the study slightly increased the bacterial densities of coliforms, fecal coliforms and fecal streptococci coming into the estuary from the upper basin. These same flow conditions, however, dramatically decreased the relatively large bacterial populations found in the metropolitan reach between the confluence with the Anacostia River down to Hallowing Point, apparently by flushing and diluting action. The lower reaches of the estuary, at least to the downstream limit of this study, were contaminated by this excursion.

Using a fecal coliform standard of 240 MPN/100 ml for water contact recreation, the Potomac Estuary from Chain Bridge to Indian Head would be unacceptable, and under some conditions, for the length

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of estuary investigated.

The distribution of the indicator species followed established patterns, i.e., coliforms most prevalent, fecal coliforms approximately a decimal order of magnitude lower, and a much more restricted distribution of fecal streptococci. The lesser numbers of the latter two are probably due in part to a lack of aftergrowth as suggested by Evan, et al (3).

Some experimental findings by other investigators indicate there may be a significance in the fecal coliform/fecal streptococci ratio (FC/FS). Geldreich (5) (6) postulated that a ratio of less than 0.7 indicates animal pollution and/or urban stormwater discharges with higher ratios presumably due to human sources.

Examination of the FC/FS ratios as presented in Table 3 indicates: (1) a much wider fluctuation of ratios in the river than in the sewage treatment plants, (2) the magnitude of the ratios in the three treatment plants tended to fluctuate together, indicating a common cause such as infiltration, and (3) a dramatic general decrease in the magnitude of the ratio in the estuary after March 5, when the river flows rose. The

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interpretation of the fluctuations in the treatment plant data is confounded in that the precipitation was in the form of snow, with thawing temperatures during the days and freezing at night. Runoff patterns as well as infiltration rates into sewage systems are difficult to establish under these conditions.

The data, assuming the FC/FS ratio is valid, indicate the major source of pollution was from human sources in the estuary during the period from February 15 through March 5, 1967. Even with a 14-fold dilution effect, as the result of the increased runoff, the ratio still indicates the source to be substantially of human origin.

Distribution of Salmonellae

Salmonellae were recovered from areas of the Potomac Estuary with chronically high coliform, fecal coliform and fecal streptococci, but not from areas where these bacterial densities were generally at acceptable levels under the environmental conditions during this study.

Table 3
FECAL COLIFORM/FECAL STREPTOCOCCI RATIOS

Potomac Estuary

February - March 1967

Station	2/15	2/16	2/23	3/2	3/3	3/4	3/5	3/6	3/7	3/8	3/9	3/13
Chain Bridge	8.5	11.5	2.4					7.2	0.72	0.86		0.40
Key Bridge	24.5	26.0									1.0	2.0
Memorial Bridge			1.1						1.6	1.9		
Rock Creek - M Street				16.5	36.7	7.0	1.2	3.7	0.18	11.5		
Bolling AFB								1.6	0.72	3.8		0.52
Wilson Bridge	20.2	28.8	13.8	8.6	700	30	19.8	6.8				2.2
Broad Creek					52.1	3.9	38.2	1.7	2.6	4.9		2.4
Fort Washington					43.5	11.1	31.9	18.6	0.70	1.0		1.8
Dogue Creek					11.1	14.0	30.0	9.8	1.4	0.35		12.2
Hallowing Point							108.4	17.0	0.76			0.22
Indian Head					60.0	35.0	34.4			6.9		0.15
Possun Point								2.0				2.2
Sandy Point												0.25
Smith Point												1.0
Maryland Point												0.33
Manjency										7.7		0.08

Table 3 (Cont.)
FECAL COLIFORM/FECAL STREPTOCOCCI RATIOS
Potomac Estuary
February - March 1967

Treatment Plant	2/2	2/3	2/6	2/13	2/14	2/15	2/17	2/20	2/21
Blue Plains	15.6		31.5	3.4/3.2	5.0/10.5	2.4/13.9	3.3/0.66	4.2	0.15/0.12
Arlington	0.86	3.9/2.6	19.5/29.7	4.9/17.1	0.64/2.7	4.9/5.0	0.62/1.3	0.78	0.22/0.30
Alexandria	2.8	0.33/7.7	3.8/4.4	6.4/13.2	5.8/35	39.9/7.1	21.2/1.4	0.42	0.18/0.08

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The Salmonella data cannot be compared with the indicator bacteria on a sound statistical basis because of their paucity and their non-parametric nature. It is instructive, however, to compare the percent of times Salmonellae were recovered with the densities of indicator organisms. Figure 7 shows the relationships found. At coliform densities less than 500 MPN/100 ml, fecal coliforms at 100 MPN/100 ml, and fecal streptococci at 20 MPN/100 ml, no Salmonellae were recovered. The greater incidence of Salmonella recovery was generally at higher indicator bacteria densities.

The incidence of Salmonellae in the Potomac Estuary confirms the usefulness of coliforms and fecal coliforms as indicators of bacterial pollution. Moreover, the high incidence of Salmonellae in waters with high bacterial densities of coliforms and fecal coliforms make the numerical indices used in water quality standards more realistic. This is contrary to some studies on fresh water rivers as reported by Gallagher and Spino (4).

All of the isolates sent to the U. S. Public Health Service Communicable Disease Center for serotyping proved to be Salmonella species. No apparent

INDICATOR - BACTERIAL DENSITY
and
SALMONELLA RECOVERY
UPPER POTOMAC ESTUARY
FEBRUARY - MARCH 1967
CHESAPEAKE TECHNICAL SUPPORT LABORATORY

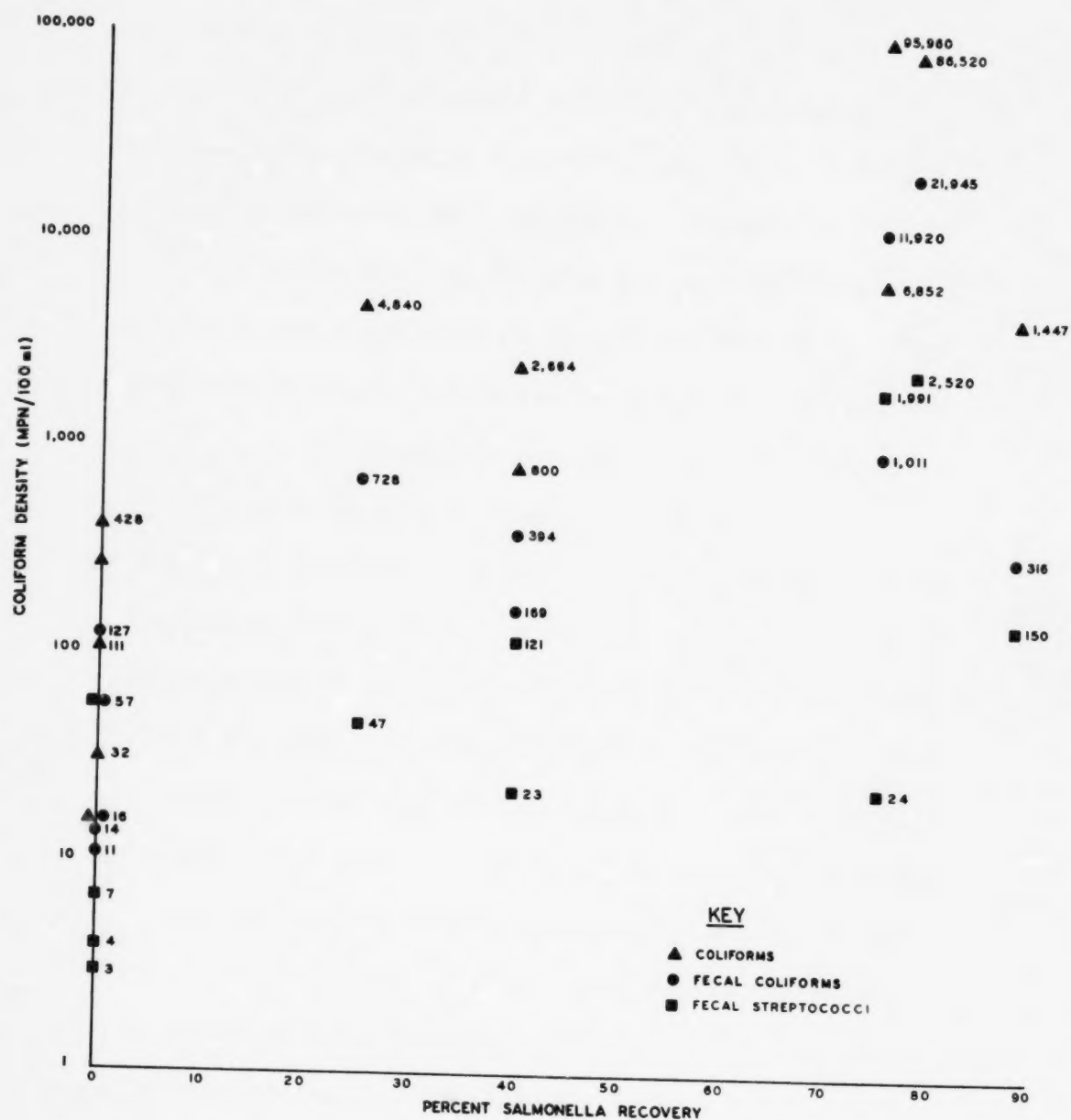


FIGURE 7

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relationships existed between the species of *Salmonella* and the distribution in the estuary, but the data are insufficient to draw sound conclusions.

SUMMARY

The findings of the sanitary bacteriological survey of the upper Potomac Estuary during January-March of 1967, are summarized below:

1. High coliform, fecal coliform and fecal streptococci densities were found in the Washington metropolitan area.
2. A potential health hazard existed in the Washington metropolitan area, with *Salmonella* organisms readily and regularly isolated.
3. Three of the four major sewage treatment plants in the Washington metropolitan area contributed large volumes of indicator bacteria as well as *Salmonellae*, to the upper Potomac Estuary.
4. A rapid rise in river flows during the study had a two-fold effect on water quality by (a) considerably reducing by dilution the bacterial densities in the upper estuary near the wastewater discharges, and

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(b) increasing the bacterial densities in the middle estuary by flushing indicator organisms downstream a distance of at least 50 miles.

5. Fecal coliform/fecal streptococci ratios indicated that the bacterial pollution in the upper Potomac Estuary was probably of human origin.

6. In general, greater incidence of *Salmonella* recovery was obtained in waters having high indicator-bacterial densities.

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U. S. DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION
CONTROL ADMINISTRATION
MID-ATLANTIC REGION

A TECHNICAL ASSESSMENT
OF
CURRENT WATER QUALITY CONDITIONS
AND
FACTORS AFFECTING WATER QUALITY
IN THE
UPPER POTOMAC ESTUARY

March 1969

PENNSYLVANIA
MARYLAND
DISTRICT OF COLUMBIA
VIRGINIA
NORTH CAROLINA
SOUTH CAROLINA

G. W. Cook

A TECHNICAL ASSESSMENT
OF
CURRENT WATER QUALITY CONDITIONS
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IN THE
UPPER POTOMAC ESTUARY

March 1969

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Technical Report No. 5
Chesapeake Technical Support Laboratory
Middle Atlantic Region
Federal Water Pollution Control Administration
U. S. Department of the Interior

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CHAPTER I

INTRODUCTION

Water quality problems in the Potomac River Basin, their sources and corrective actions required, are the subject of continuing investigations by the Chesapeake Technical Support Laboratory (CTSL)* of the Middle Atlantic Region (MAR) of the Federal Water Pollution Control Administration (FWPCA) in conformance with provisions of the Federal Water Pollution Control Act, as amended (33 U.S.C. 466 et seq.). A map of the Potomac Estuary is presented in Figure I-1.

Initially, emphasis was placed on water quality monitoring and the application and verification of mathematical models capable of simulating the effects of low-flow augmentation, wastewater diversion, water supply withdrawals and increased degrees of wastewater treatment on dissolved oxygen (DO), phosphorus, and chloride concentrations in the estuary. The use of

* Formerly the Chesapeake Field Station

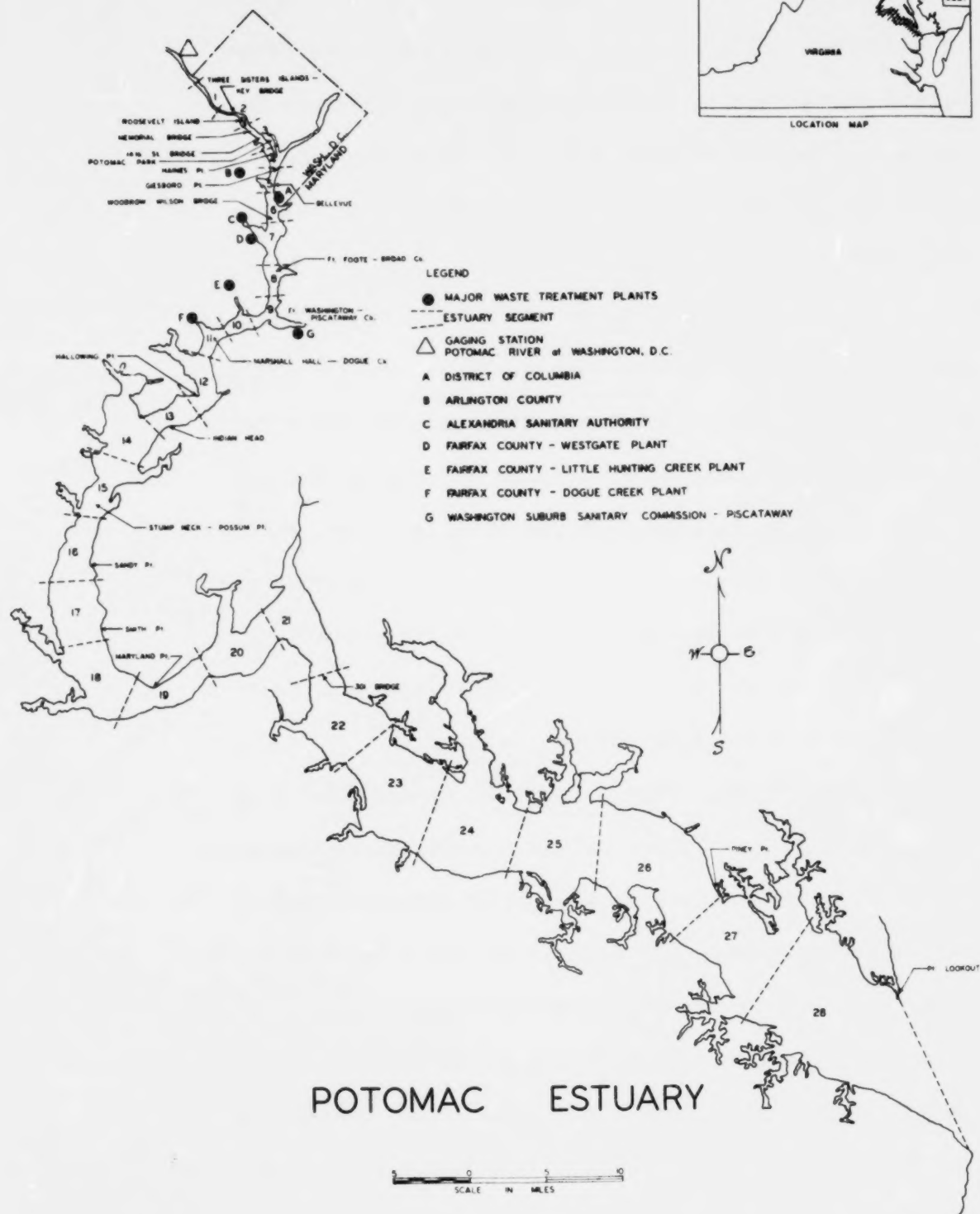


FIGURE 1-1

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mathematical model not only provides predictive capability for effect of future wastewater discharges in the upper Potomac Estuary but also furnishes a means of investigating biological and environmental conditions affecting dissolved oxygen.

Using the report "A Research Program for the Potomac River" by Dr. John C. Geyer, et al. (1) as a guide, studies were instituted to determine the effects of benthic deposits, nitrification and phytoplankton activity on the dissolved oxygen balance in the estuary. Investigations were also made to determine sources and rate limiting concentrations of various measurable nutrients which, if controlled, could alleviate eutrophic conditions in the upper Potomac Estuary.

This report includes an assessment of the current (1968) water quality conditions and factors affecting water quality in the upper Potomac Estuary. It includes the sources and effects of the nutrients on the production of massive phytoplankton growths; and, finally, it contains an evaluation of all major sources of carbonaceous and nitrogenous BOD including wastewater discharges, benthic background, and phytoplankton growths and their effects on the DO balance.

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This report is one of a series prepared by CTSL on various aspects of the water quality management in the Potomac River Basin (2) (3) (4) (5) (6) (7) (8).

CHAPTER II

CURRENT WATER QUALITY CONDITIONS

The water quality conditions in the Potomac Estuary are monitored, usually weekly, by CTSL and by the Department of Sanitary Engineering of the District of Columbia. The results of the monitoring program for the months of May through October 1968 are presented herein. The fresh water inflow, water temperature, and solar radiation for the six-month time period are presented in Figure II-1.

A. Fecal Coliform Densities

As can be seen in Figure II-2, high fecal coliform densities, over 1000 MPN/100 ml, were detected in a reach of the upper estuary from Memorial Bridge

FRESH WATER INFLOW, WATER TEMPERATURE, and SOLAR RADIATION
UPPER POTOMAC ESTUARY
MAY to OCTOBER 1968

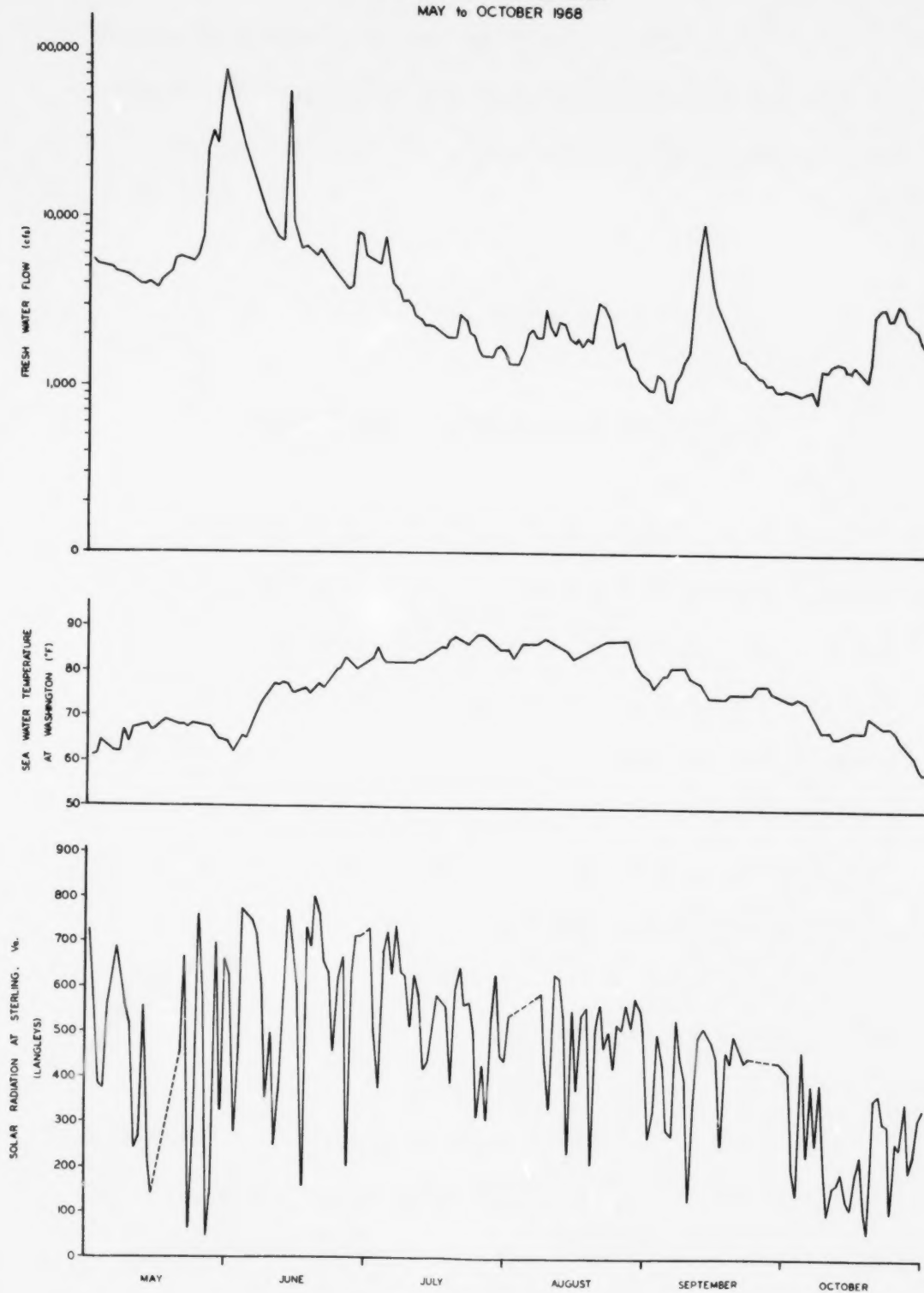


FIGURE 11-1

FECAL COLIFORM ISOPLETH
(MPN/100ml)
UPPER POTOMAC ESTUARY
MAY to OCTOBER 1968
CHESAPEAKE TECHNICAL SUPPORT LABORATORY

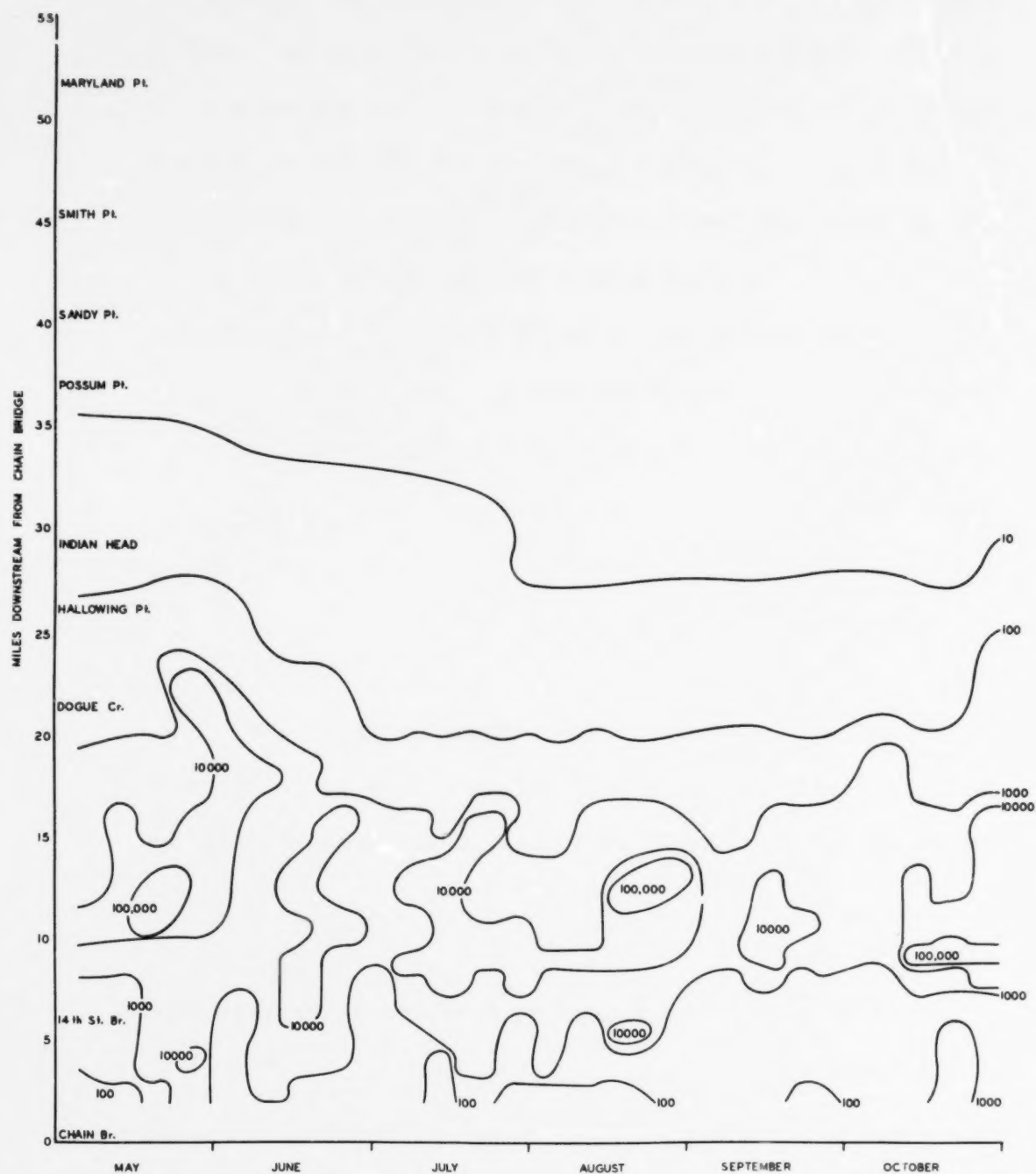


FIGURE 11-2

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(River Mile 4.8)* to Piscataway Creek (River Mile 18.0). Fecal coliform densities over 10,000 were also detected principally in the reach between Bellevue (River Mile 9.7) and Woodrow Wilson Bridge (River Mile 11.8). The fecal coliform water quality standards for the waters of the Potomac Estuary are 240 and 200 MPN/100 ml maximum for Maryland and the District of Columbia, respectively.

In the middle reaches of the estuary below Indian Head (River Mile 29.5), the fecal coliform densities were below 10 MPN/100 ml. No routine bacterial analyses were made in the main channel of the lower estuary.

B. Dissolved Oxygen (DO)

The dissolved oxygen levels in the estuary from Memorial Bridge (River Mile 4.8) to Hallowing Point* (River Mile 26.0) were usually less than 6.0 mg/l

* River miles are the distances measured downstream from Chain Bridge.

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as presented in an isopleth* in Figure II-3. During the months of July through October, when the fresh water flow into the estuary was less than 2000 cfs, the DO in the reach from Haines Point (River Mile 7.4) to Dogue Creek (River Mile 22.4) often dropped below 4.0 mg/l. Periods of less than 2.0 mg/l dissolved oxygen concentration were observed in the reach from Haines Point to Broad Creek. The DO water quality standards for the waters of the upper Potomac Estuary are an average of 5.0 and 4.0 mg/l for Maryland and the District of Columbia, respectively.

* An isopleth, which exhibits a complete graphical presentation of water quality with respect to location and time along the estuary, is useful for depicting variations of a parameter at a given location for a specific time or for a given time period along the estuary. The isopleths were constructed by plotting all data for a given station along the estuary for the six-month period. A smooth curve was fitted to these data as representative of "average" conditions during the entire survey period.

DISSOLVED OXYGEN ISOPLETH
(mg/l)
UPPER POTOMAC ESTUARY
MAY to OCTOBER 1968
CHESAPEAKE TECHNICAL SUPPORT LABORATORY



FIGURE 11-3

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In the upper part of the estuary near Fletcher's Boat House (River Mile 2.0), the DO was usually 8.0 mg/l and greater. Generally, dissolved oxygen concentrations between 6.0 and 8.0 mg/l were detected in the middle part of the estuary from Indian Head to the Route 301 Bridge (River Mile 57.5).

C. Biochemical Oxygen Demand (BOD)

1. Sources of BOD

The four principal sources of BOD in the estuary are:

- a. Wastewater - carbonaceous,
- b. Wastewater - nitrogenous,
- c. Algal - carbonaceous and nitrogenous, and
- d. Benthic-background - carbonaceous and nitrogenous.

The carbonaceous and nitrogenous BOD,* including nutrients from the wastewater discharges, were routinely monitored by the personnel of the various treatment facilities and were intensively sampled during the special surveys of August 19 to 22, 1968, and

* BOD is 5-day BOD at 20°C unless stated otherwise.

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February 11 to 13, 1969, by CTSL. A tabulation of the wastewater treatment plant BOD and nutrient loadings for the August 1968 survey is presented in Table II-1. A summary of BOD and nutrient loadings from wastewater discharges and the fresh water inflow for the August 1968 survey is presented in Table II-2.

2. BOD Concentrations in the Estuary

In the reach from Chain Bridge (River Mile 0.0) to Piscataway Creek (River Mile 18.0) the BOD concentrations were increased from an average of 3.0 mg/l to over 10.0 mg/l and greater at times by wastewater discharges (Figure II-4). The high BOD level in the reach from Piscataway to Indian Head was due primarily to algal carbon. This will be discussed later in this report.

D. Nutrients - Phosphorus and Nitrogen

1. Sources of Nutrients

In 1966, an extensive sampling program was initiated by CTSL to determine the sources, spatial distribution, transport mechanisms, etc., of nutrients in the Potomac River Basin (8). The delineation of the sources as presented in Tables II-3 and II-4 indicates the following for an average stream flow year:

Table II - 1

WASTEWATER LOADINGS
Potomac Estuary Intensive Survey
August 19-22, 1968
Chesapeake Field Station

Treatment Facility	Population Served	Flow (mgd)	BOD		S. Solids		TKN as N		TPO ₄ as PO ₄		NH ₃ as N	TOC
			Untreated (#/day)	Treated (#/day)	Untreated (#/day)	Treated (#/day)	Untreated (#/day)	Treated (#/day)	Untreated (#/day)	Treated (#/day)	Untreated (#/day)	Treated (#/day)
Pentagon	42,000	1.33	2,800	320	2,400	90	160	120	290	220	110	260
Arlington	186,000	21.30	34,000	4,100	36,000	7,300	4,600	3,400	5,700	5,300	2,100	4,300
Overflows 2.7 of D. C.	-	7.10	8,400	8,400	9,600	9,600	1,300	1,300	1,400	1,400	700	5,900
District of Columbia	1,750,000	261.00	307,000	92,000	353,000	114,000	48,000	40,000	52,000	44,000	20,000	72,000
Alexandria	180,000	19.80	31,000	8,300	30,000	7,500	4,300	3,600	5,400	4,700	2,300	6,900
F. Westgate	127,000	11.28	28,300	14,500	21,000	10,300	2,900	2,500	3,200	3,000	1,100	10,000
Piscataway	50,000	5.00	6,700	540	5,100	460	700	600	1,500	920	440	840
Andrews AFB #1	8,000	0.71	1,700	200	1,000	140	110	50	170	80	30	70
Andrews AFB #4	1,000	0.07	180	30	70	10	10	3	20	12	2	8
F. Hunting Creek	33,000	2.87	5,400	820	4,400	760	720	640	1,000	950	310	850
F. Dogue Creek	16,000	1.36	3,100	430	3,100	400	360	260	460	450	160	360
Pt. Belvoir #1	3,500	0.55	1,100	180	1,300	240	90	60	60	20	50	100
Pt. Belvoir #2	18,400	1.58	2,900	380	2,600	260	290	260	450	230	170	300
Total	2,414,900	334.15	428,000	130,200	469,570	151,060	63,540	52,793	71,650	61,282	27,472	101,893
Per capita/day	-	138 (gpcd)	0.177 (gpcd)	0.0521 (gpcd)	0.194 (gpcd)	0.061 (gpcd)	0.026 (gpcd)	0.021 (gpcd)	0.029 (gpcd)	0.025 (gpcd)	0.011 (gpcd)	0.042 (gpcd)

TABLE II-2
 SUMMARY OF BOD AND NUTRIENT LOADINGS
 Upper Potomac Estuary
 August 19-22, 1968

<u>Parameter</u>	<u>Unit</u>	<u>Wastewater Discharges</u>	<u>Fresh Water* Inflow</u>
Flow	mgd	334	1,780
BOD	lbs./day	130,000	52,800
TOC	lbs./day	101,000	87,500
TKN as N	lbs./day	52,800	14,500
NO ₂ +NO ₃ as N	lbs./day	insignificant	1,500
NH ₃ as N	lbs./day	27,500	1,800
TP as PO ₄	lbs./day	61,300	4,800

* Based on flows and concentrations for Potomac River at Little Falls.

TOC, = Total organic carbon
 TKN = Total Kjeldahl nitrogen
 TP = Total phosphorus

BOD ISOPLETH
(mg/l)
UPPER POTOMAC ESTUARY
MAY to OCTOBER 1968
CHESAPEAKE TECHNICAL SUPPORT LABORATORY



FIGURE 11-4

TABLE II-3

AVERAGE TOTAL PHOSPHORUS LOADINGS AS PO_4

Potomac River Basin

Area	In Wastewater Discharges (lbs./day)	From Land and Other Sources (lbs./day)		Total (lbs./day)
Upper Potomac (Above Great Falls)	22,000	5,800*		27,800
Lower Potomac (Below Great Falls)	64,200	1,600**		65,800
Total	86,200	7,400		93,600

* Based on an average flow at Great Falls of 10,800 cfs and a background concentration of 0.1 mg/l of phosphorus as PO_4 or a daily yield of 0.51 lbs./sq.mile/day.

** Based on a yield of 0.51 lbs./sq.mile/day for the lower portion of the basin with a drainage area of 3,100 square miles.

TABLE II-4

AVERAGE TOTAL NITROGEN LOADINGS AS N
Potomac River Basin

Area	In Wastewater Discharges		From Land and Other Sources		Total (TKN + NO ₂ +NO ₃) (lbs./day)
	TKN (lbs./day)	NO ₂ +NO ₃ (lbs./day)	TKN (lbs./day)	NO ₂ +NO ₃ (lbs./day)	
Upper Potomac (Above Great Falls)	11,000	Insignificant	21,000*	48,000**	80,000
Lower Potomac (Below Great Falls)	54,300	Insignificant	5,600*	12,800**	72,700
Total	65,300	Insignificant	26,600	60,800	152,700

* Based on an average flow at Great Falls of 10,800 cfs and a background concentration of 0.36 mg/l of TKN as N or a yield of 1.6 lbs./sq.mile/day for the lower Potomac.

** Based on a predicted total nitrogen loading at Great Falls of 80,000 lbs./day minus the TKN contribution or a yield of 4.15 lbs./sq.mile/day for the lower Potomac.

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a. Of the 93,600 lbs. per day of total phosphorus as PO_4 which enter the surface waters of the basin, over 92 percent on the average comes from wastewater discharges.

b. Of the 93,600 lbs. per day of PO_4 , 62,000 lbs. per day or 66 percent enter the upper Potomac Estuary from wastewater discharges.

c. The total loading of nitrogen as N to the surface waters of the basin from all sources is about 152,700 lbs. per day, of which 65,300 lbs. per day or 42 percent are from wastewater discharges.

d. About 36 percent of the total nitrogen loading is from wastewater discharges in the upper Potomac Estuary.

Another important aspect of the nutrient problem in the upper estuary is the annual variation in nutrient contribution by the sources. The average monthly loadings from the wastewater discharges in the upper estuary are relatively uniform when compared to the great variations in loadings from the upper Potomac River Basin. As can be seen in Table II-5, the average monthly loading of nitrite-nitrate nitrogen can vary from 17,400 to about 174,800 lbs. per day.

TABLE II-5

PREDICTED AVERAGE MONTHLY NUTRIENT LOADINGS

POTOMAC RIVER

NEAR WASHINGTON, D. C.

Month	Flow*	TPH_4 as O_4	TKN as N	$\text{NO}_2 + \text{NO}_3$ as N
	(cfs)	(lbs./day)	(lbs./day)	(lbs./day)
Jan.	13,590	26,130	9,820	88,600
Feb.	16,630	33,151	11,610	121,000
March	21,090	43,870	14,140	174,800
April	20,000	41,210	13,530	161,000
May	14,450	28,090	10,340	97,400
June	8,688	15,420	6,780	44,370
July	5,456	8,900	4,610	21,600
Aug.	6,113	10,180	5,060	25,760
Sept.	4,747	7,560	4,100	17,400
Oct.	6,310	10,580	5,200	27,060
Nov.	6,575	11,100	5,380	28,800
Dec.	9,886	17,950	7,540	54,200
Average	11,128	21,180	8,175	71,830

* Average monthly flows adjusted for diversions.

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These variations are more pronounced when daily values are considered. For example, in August of 1966, with a flow of about 540 cfs entering the estuary less than 1000 lbs. per day of phosphorus as PO_4 and $NO_2 + NO_3$ as N entered the upper estuary from the upper Potomac River Basin, while in February with a flow greater than 40,000 cfs, about 48,000 and 354,000 lbs. per day of phosphorus and $NO_2 + NO_3$ nitrogen, respectively, entered the estuary.

The transport mechanisms and rates for the varying nutrient loadings in the Potomac Estuary are currently under investigation by CTSL.

2. Nutrient Concentrations in the Estuary

As presented in Figure II-5, the total Kjeldahl nitrogen (TKN)* concentrations are the highest in the reach from the 14th Street Bridge (River Mile 6.0) to Indian Head (River Mile 29.0). In the upper estuary near Woodrow Wilson Bridge (River Mile 11.8), concentrations of 3.0 mg/l and greater were observed in July and August.

* TKN parameter includes both organic and NH_3 nitrogen.

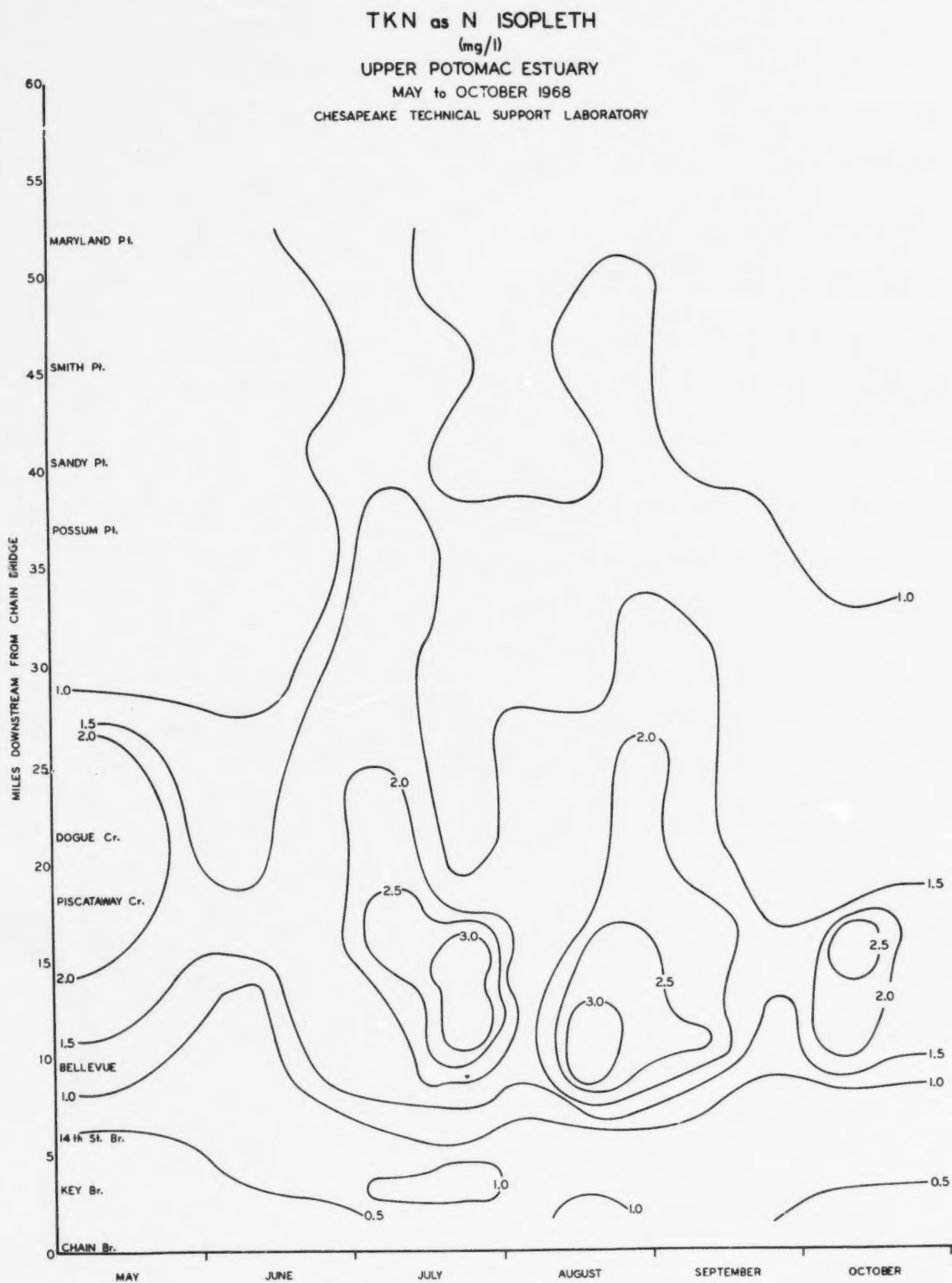


FIGURE 11-5

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The end product of the oxidation of TKN is nitrite ~~nitrate~~ nitrogen. As shown in Figure II-6, the high concentrations of $\text{NO}_2 + \text{NO}_3$ (above 1.5 mg/l) are farther downstream and there is a lag in time when compared to the level of TKN in the estuary. The significance of this oxidation process is discussed later in this report.

The TKN and $\text{NO}_2 + \text{NO}_3$ concentrations of the water entering the estuary during the months of July through October were about 0.7 and less than 0.1 mg/l, respectively.

The phosphorus concentrations were similar to TKN levels during the period from May through October (Figure II-7). During the months of August, September and October, the concentration of phosphorus was 2.0 mg/l and greater in the vicinity of Woodrow Wilson Bridge.

The concentration of phosphorus in the waters entering the estuary varied from 0.16 to 0.423 mg/l.

E. Algal Standing Crop

$\text{NO}_2 + \text{NO}_3$ as N ISOPLETH
(mg/l)
UPPER POTOMAC ESTUARY
MAY to OCTOBER 1968
CHESAPEAKE TECHNICAL SUPPORT LABORATORY

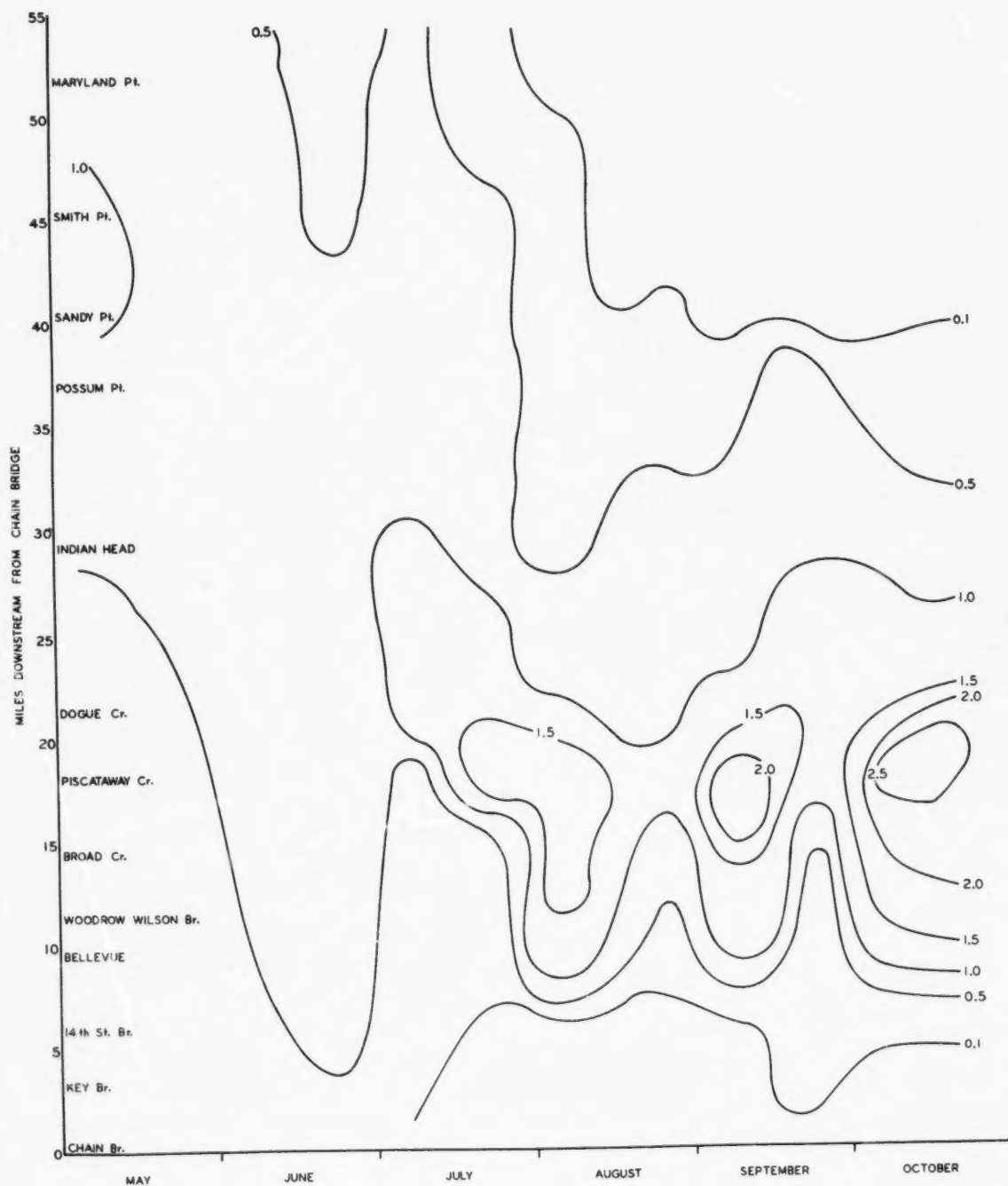


FIGURE 11-6

TOTAL P as PO_4 ISOPLETH
(mg/l)
UPPER POTOMAC ESTUARY
MAY to OCTOBER 1968
CHESAPEAKE TECHNICAL SUPPORT LABORATORY

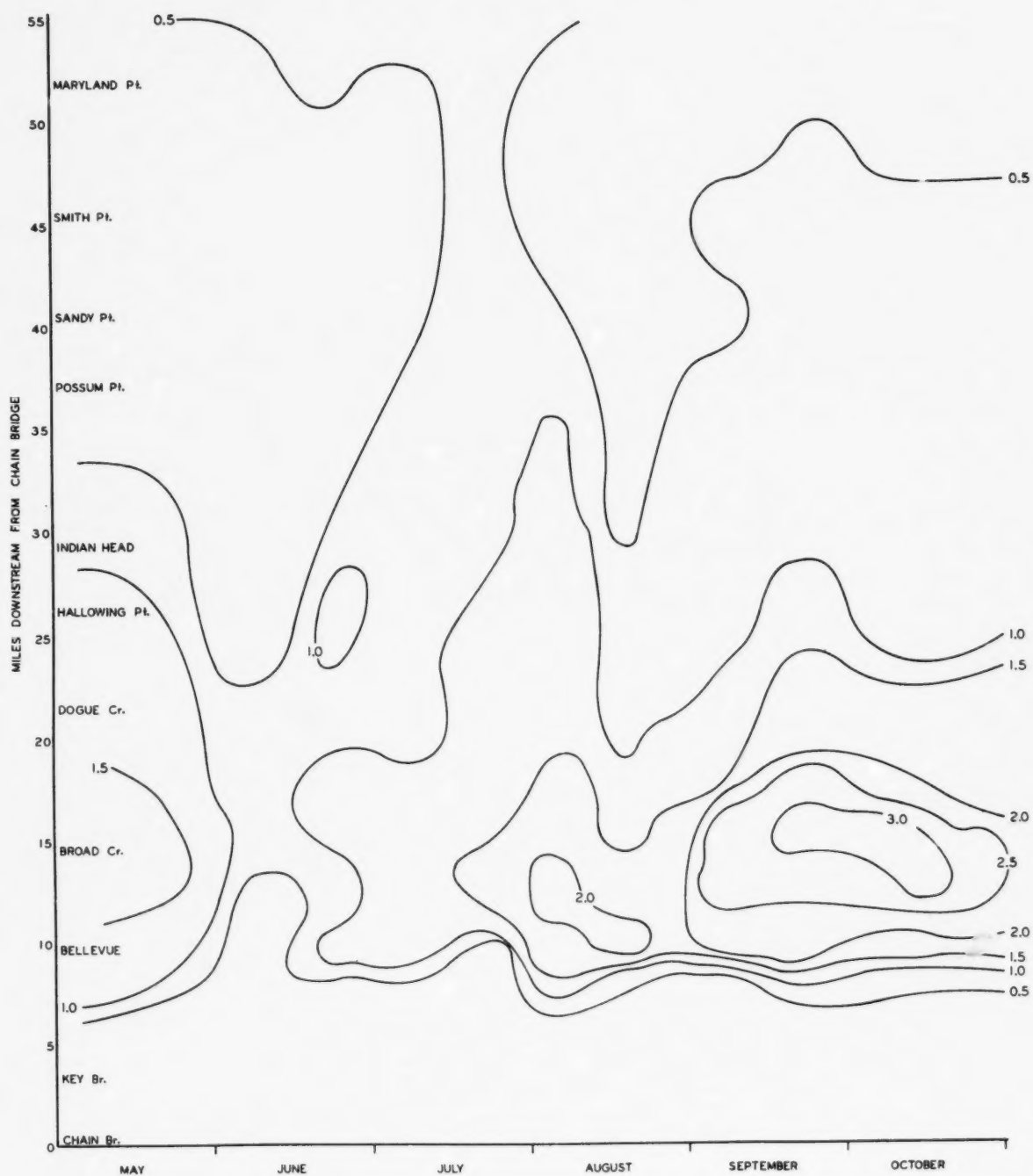


FIGURE 11-7

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Using chlorophyll "a" as a measure of algal standing crop, the isopleth as presented in Figure II-8 indicates that there was a widespread bloom* in the Potomac Estuary during the summer months of 1968. For the month of August, chlorophyll levels of 150 $\mu\text{g}/\text{l}$ and greater were observed from Bellevue (River Mile 9.7) to Hallowing Point (River Mile 26.0).

During the months of May and June, the predominant algal species in the upper estuary was *Chlamydomonas* sp., a green flagellate. During the months of July through September the predominant species was *Anacystis cyanea*, a coccoid blue-green algae. During the month of November, the predominant phytoplankton was *Chlorella*, a coccoid green algae.

* When chlorophyll levels are 50 $\mu\text{g}/\text{l}$ and greater, bloom conditions are assumed to exist.

CHLOROPHYLL ISOPLETH
($\mu\text{g/l}$)
UPPER POTOMAC ESTUARY
MAY to OCTOBER 1968
CHESAPEAKE TECHNICAL SUPPORT LABORATORY

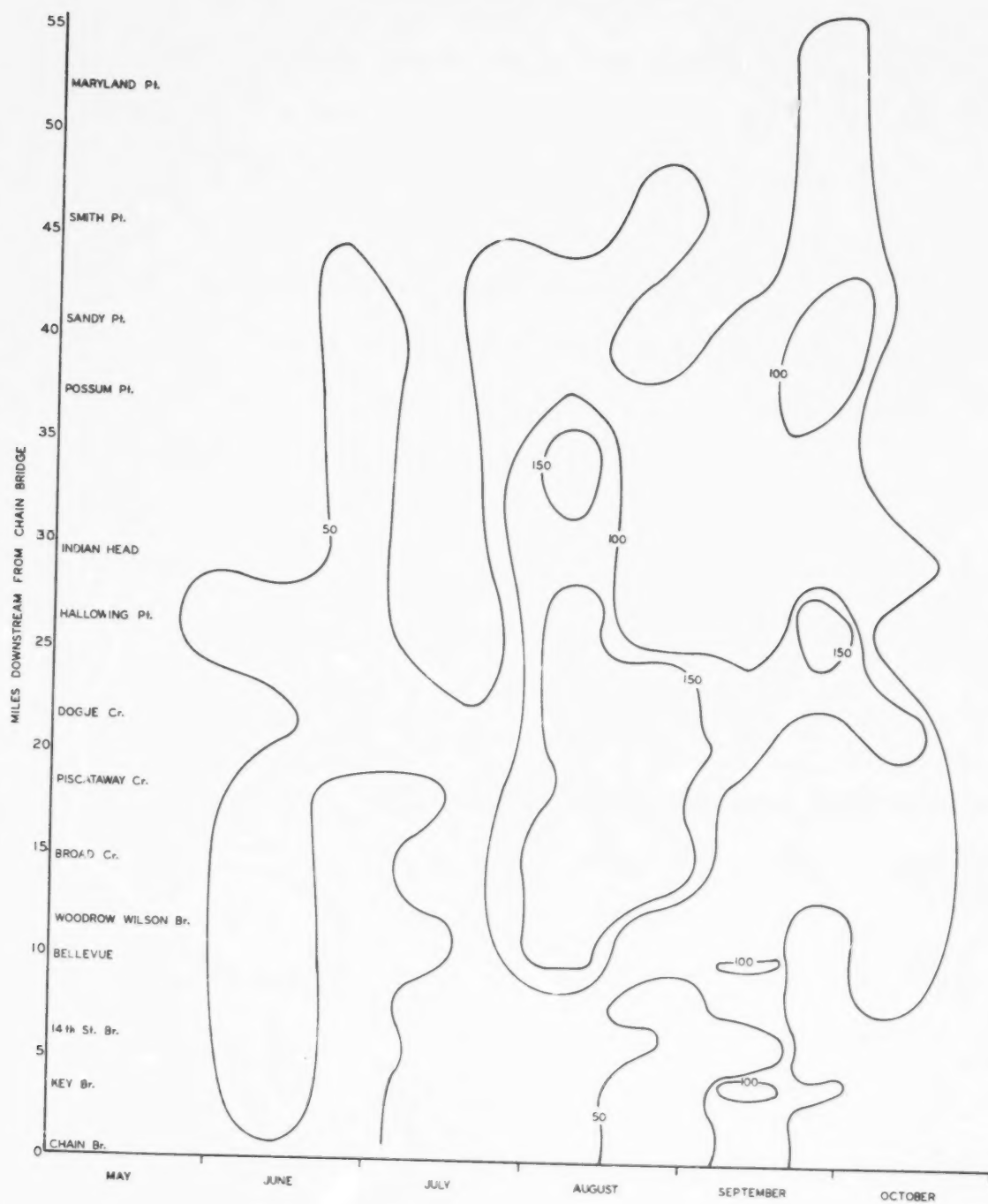


FIGURE 11-8

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CHAPTER III

NUTRIENT-ALGAL RESPONSE AND ENVIRONMENTAL REQUIREMENTS

As presented in Figure II-8, the chlorophyll levels during the months of June through October 1968 were generally greater than 50 $\mu\text{g}/\text{l}$ for approximately 50 miles of the upper estuary. Similar chlorophyll levels were also observed in the upper estuary during summer months of 1965, 1966 and 1967.

In an effort to determine rate limiting concentrations of various measurable nutrients, which if controlled could alleviate the eutrophic conditions in the upper Potomac Estuary, an analysis of data from intensive surveys and routine monitoring stations has been undertaken at CTSL. Statistical analyses were also made on other areas for comparison as presented in Table III-1.

In the analyses, the following parameters were investigated:

TABLE III-1

NUTRIENT-CHLOROPHYLL DATA SOURCES

<u>Data Source Number</u>	<u>Water Course</u>	<u>Year Collected</u>	<u>Agency</u> C B I
I	Potomac Estuary Middle-lower	1965-1966	Johns Hopkins Univ.
II	Potomac Estuary a - upper b - middle c - lower	1965-1966	CFS, FWPCA
III	Potomac Estuary a - upper b - middle c - lower embayments	1967-1968	CFS, FWPCA
IV	Patuxent Estuary a - upper-middle	1968	CFS, FWPCA
V	James Estuary		Va. Institute of Marine Science
VI	Upper Chesapeake Bay a - Northeast River b - Upper Bay	1968	CFS, FWPCA
VII	Middle Chesapeake Bay	1967-1968	CFS, FWPCA

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1. Total Phosphorus
2. Inorganic Phosphorus
3. NO_2 -Nitrogen
4. NO_3 -Nitrogen
5. TKN Nitrogen
6. NH_3 -Nitrogen
7. Temperature
8. Secchi Disc (Measure of light extinction)
9. Nitrogen/Phosphorus Ratio
10. Salinity
11. TOC

By grouping the data, the physical effects of fresh water inflow, channel-depth, tidal velocity, salinity, etc., on the algal standing crop were also investigated.

Preliminary results of the statistical analyses for the Potomac Estuary and the other eutrophic areas are presented below.

A. Phosphorus

A nutrient which has been often related to

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nuisance algal blooms is phosphorus. To determine if increase in algal growths in the Potomac Estuary is related to the high phosphorus levels, analyses of the data from the years 1965-1968 primarily for the summer conditions were made.

Figure III-1 is a graphical presentation of the chlorophyll-phosphorus relationship developed by plotting the mean phosphorus* versus the mean chlorophyll levels for the various areas indicated in Table III-1. From the graphical presentation, it appears that when the phosphorus level is below 0.6 mg/l growth-dependent conditions occur (i.e., under these conditions, the chlorophyll level or standing stock is directly proportional to the phosphate concentration present). Above 0.6 mg/l of phosphate the chlorophyll appears to be constant and independent of the phosphorus concentration.** Similar observations with regards to growth response

* In this report all phosphorus concentrations are given as total phosphorus as PO_4 unless stated otherwise.

** Above this concentration, "luxury uptake" of phosphorus occurs.

CHLOROPHYLL - TOTAL PHOSPHORUS CONCENTRATIONS
SUMMER CONDITIONS
FOR VARIOUS AREAS OF THE CHESAPEAKE BAY SYSTEM

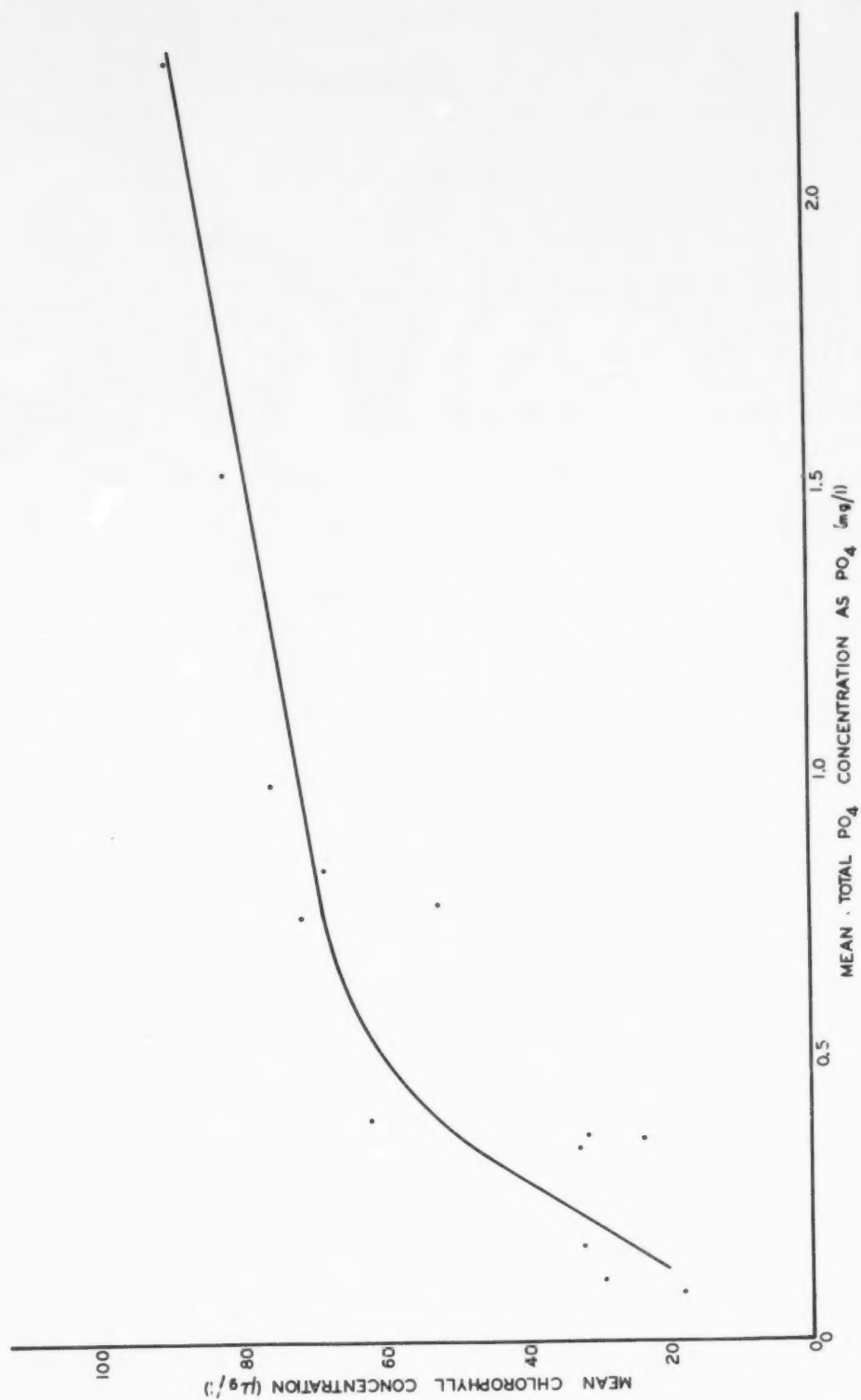


FIGURE III-1

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have been made by Borchardt and Azad (9) in studying phosphorus uptake by algal cultures in the laboratory.

In Figure III-2 is exhibited chlorophyll inorganic phosphorus concentration for the 1966 summer intensive survey by CTSL. Sampling stations in the Potomac Estuary are shown in Figure I-1. The relationship is very similar to that of the entire Chesapeake Bay system, as presented in Figure III-1.

From the relationships in Figures III-1 and III-2, it appears that nuisance algal bloom (above 50 $\mu\text{g}/\text{l}$ of chlorophyll) can be reduced significantly in the Potomac Estuary if the total phosphorus level is maintained below 0.39 mg/l as PO_4 or in terms of inorganic phosphorus, 0.30 mg/l. This is assuming that all other algal growth conditions are favorable.

B. Nitrogen

The analyses of nitrogen-algal relationships are more complex than phosphorus-algal responses in that the predominant form of nitrogen entering the estuary can be either NH_3 , NO_3 or organic. During spring high flows, the nitrate-nitrogen form, primarily from

CHLOROPHYLL - INORGANIC PHOSPHORUS CONCENTRATIONS
 POTOMAC ESTUARY
 INTENSIVE SURVEY - 1966

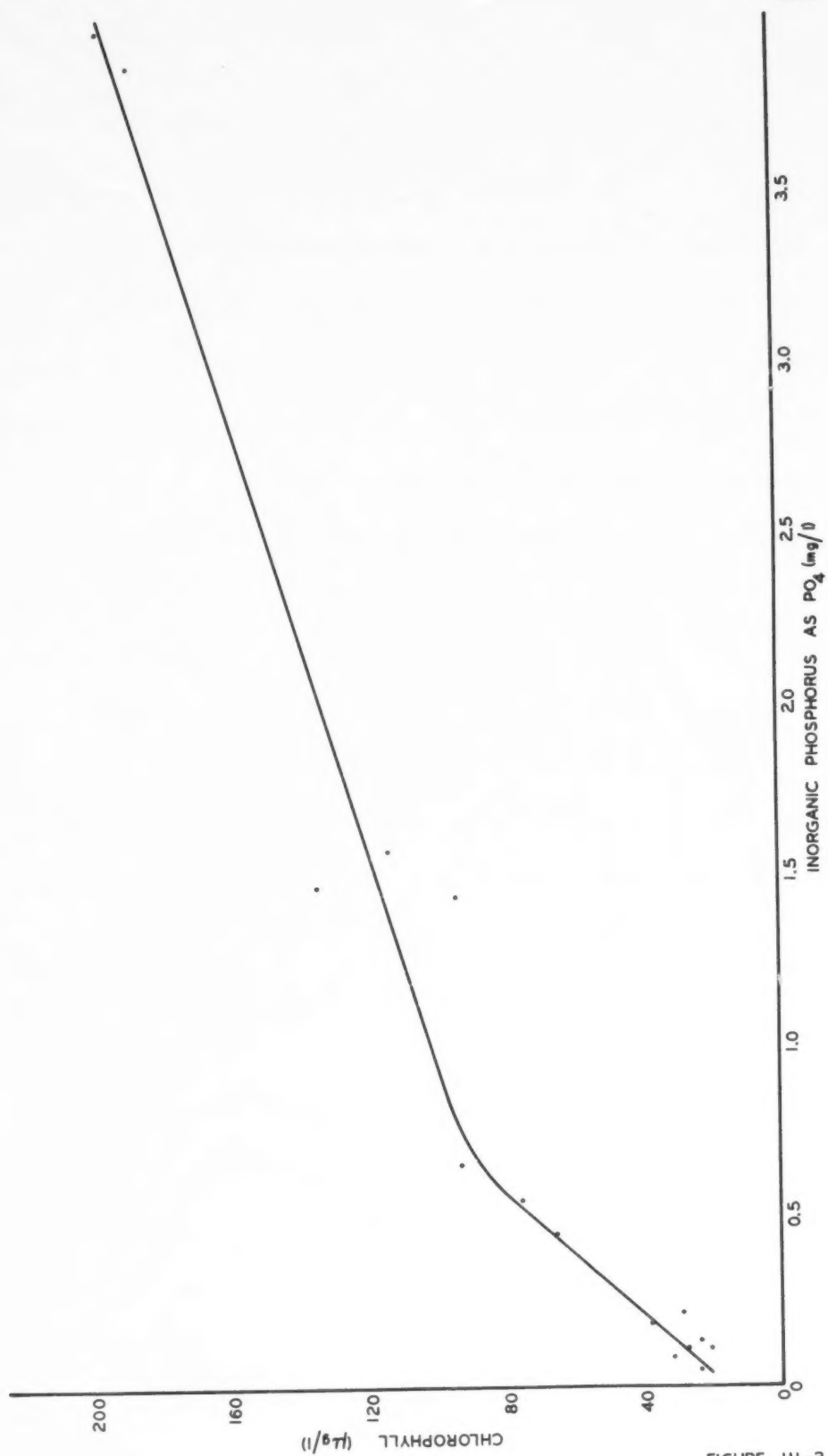


FIGURE III-2

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land runoff, is the most abundant.

Coupled to varying forms of nitrogen entering the estuary are the biochemical dynamics of the nitrogen cycle itself. During the summer months, most of the ammonia and some of the organic nitrogen from wastewater discharges are oxidized to nitrate-nitrogen as exemplified by the August 1968 survey. (See Figure III-3.) The nitrate form is then taken up by the algae and converted into organic nitrogen as part of the cell.

Mass balances of the various nitrogen fractions, phosphorus, and chlorophyll were made utilizing the data from the intensive surveys. The balances, or more specifically, instantaneous loading rates, were calculated by the formulation as presented below:

$$P = L \times A \times C \times F$$

where

P = Loading rate in a given cross-section (lbs./linear ft.)

L = One linear foot of estuary (ft.)

A = Cross-section area (ft²)

C = Average concentration of parameter in cross-section (mg/l)

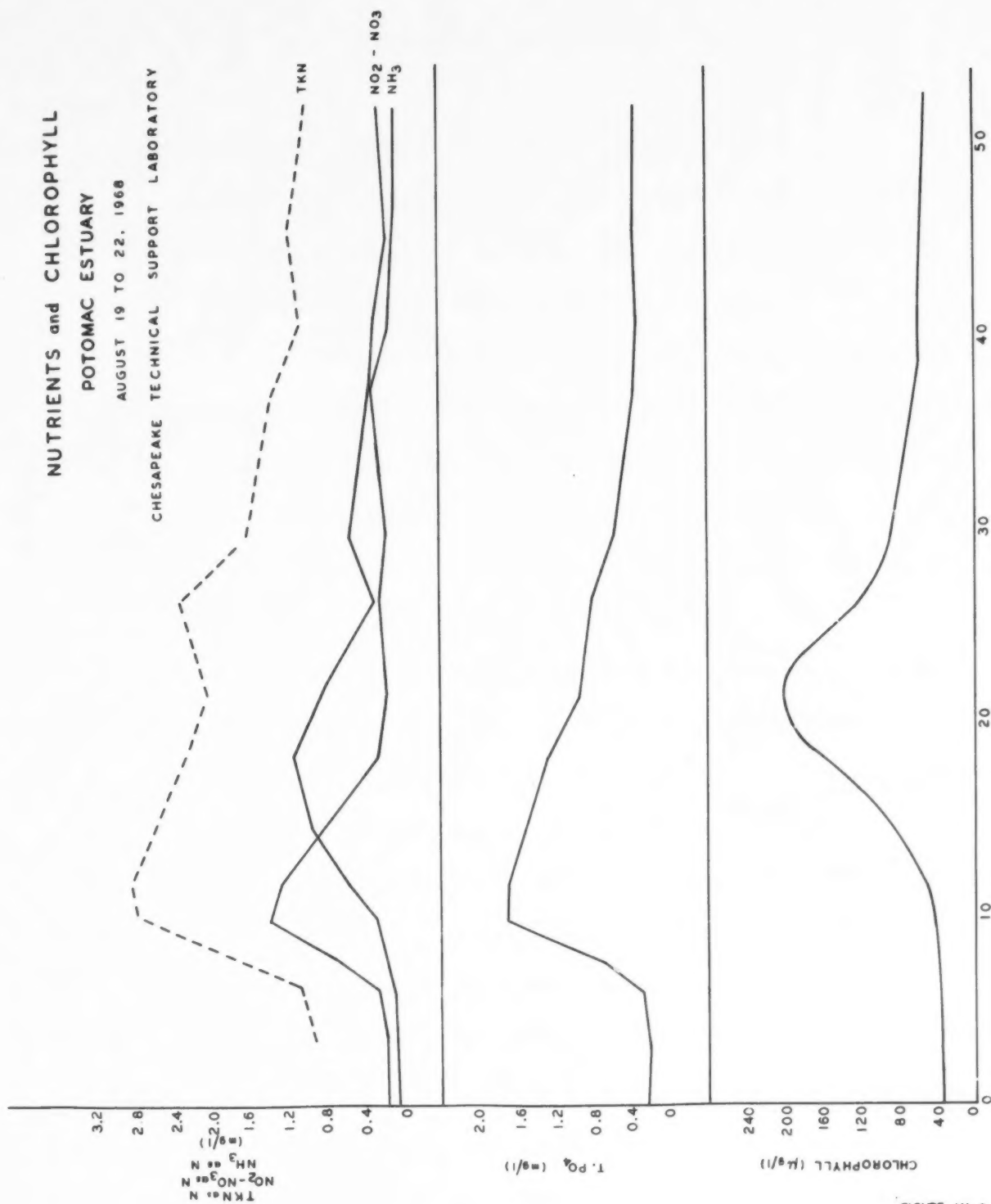


FIGURE III-3

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F = A conversion factor.

The dynamics of the nitrogen system are shown in Figure III-4, which is a graphical presentation of the instantaneous loading rates for the August 19-22, 1968, survey. From River Mile 0.0 to River Mile 10.0, there is a rapid increase in TKN and NH_3 loading. Starting at River Mile 2.0, the nitrate loading starts to increase with a maximum loading rate at River Mile 20.0 which corresponds to the minimum loading rate of NH_3 downstream from the wastewater discharge.

In the reach from River Mile 30 to 50, the nitrate loading decreases to less than 1 lb. per linear foot. This decrease in nitrate is attributed to utilization by the algal cells.

The mass balances as presented in Figure III-3 also indicate that most of the phosphorus moves downstream. This constant loading rate for phosphorus corroborates the works of Hayes (10) in which he stated that the recycling time of inorganic PO_4 by phytoplankton and bacterial cells is very short, less than one day. Mass balances for other surveys indicate similar downstream movement except in the upper estuary

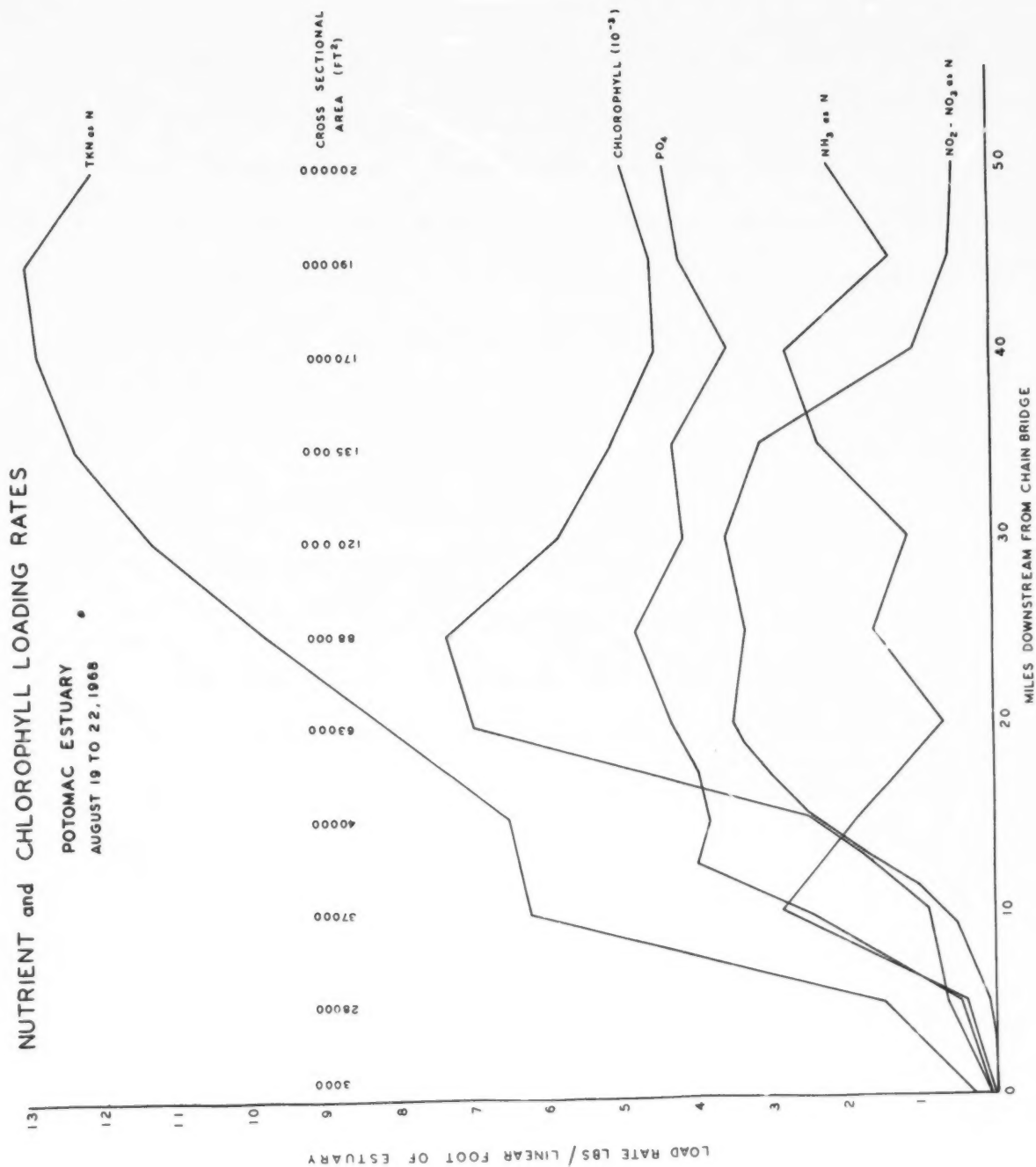


FIGURE III-4

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during periods of low flow. Under low flow conditions, the concentration of phosphates is often above 2.0 mg/l and considerable **depositions** occur. Deposition to the bottom muds occurs at lower phosphorus levels in the middle and lower portions of the estuary as supported by data from recent Potomac Estuary sediment surveys. however, the rate of deposition is much less at low concentrations.

In Figure III-5 is a graphical presentation of the nitrate-nitrogen-chlorophyll concentrations for the same conditions as in Figure III-1 for phosphorus. When the areas with phosphorus concentrations of less than 0.39 mg/l are noted, the relationship between chlorophyll and inorganic nitrogen appears to be significant.

For the 1966 and 1968 intensive surveys in the Potomac Estuary, the relationships of chlorophyll to $\text{NO}_2 + \text{NO}_3$ nitrogen are more pronounced, as can be seen in Figure III-6. Moreover, the relationship is linear with no point of "luxury uptake" as with phosphorus.

Using the 50 $\mu\text{g/l}$ of chlorophyll level as for phosphorus and the relationships in Figures III-5 and III-6, maintaining of concentrations of less than

CHLOROPHYLL - INORGANIC NITROGEN CONCENTRATIONS
 SUMMER CONDITIONS
 FOR VARIOUS AREAS OF THE CHESAPEAKE BAY SYSTEM

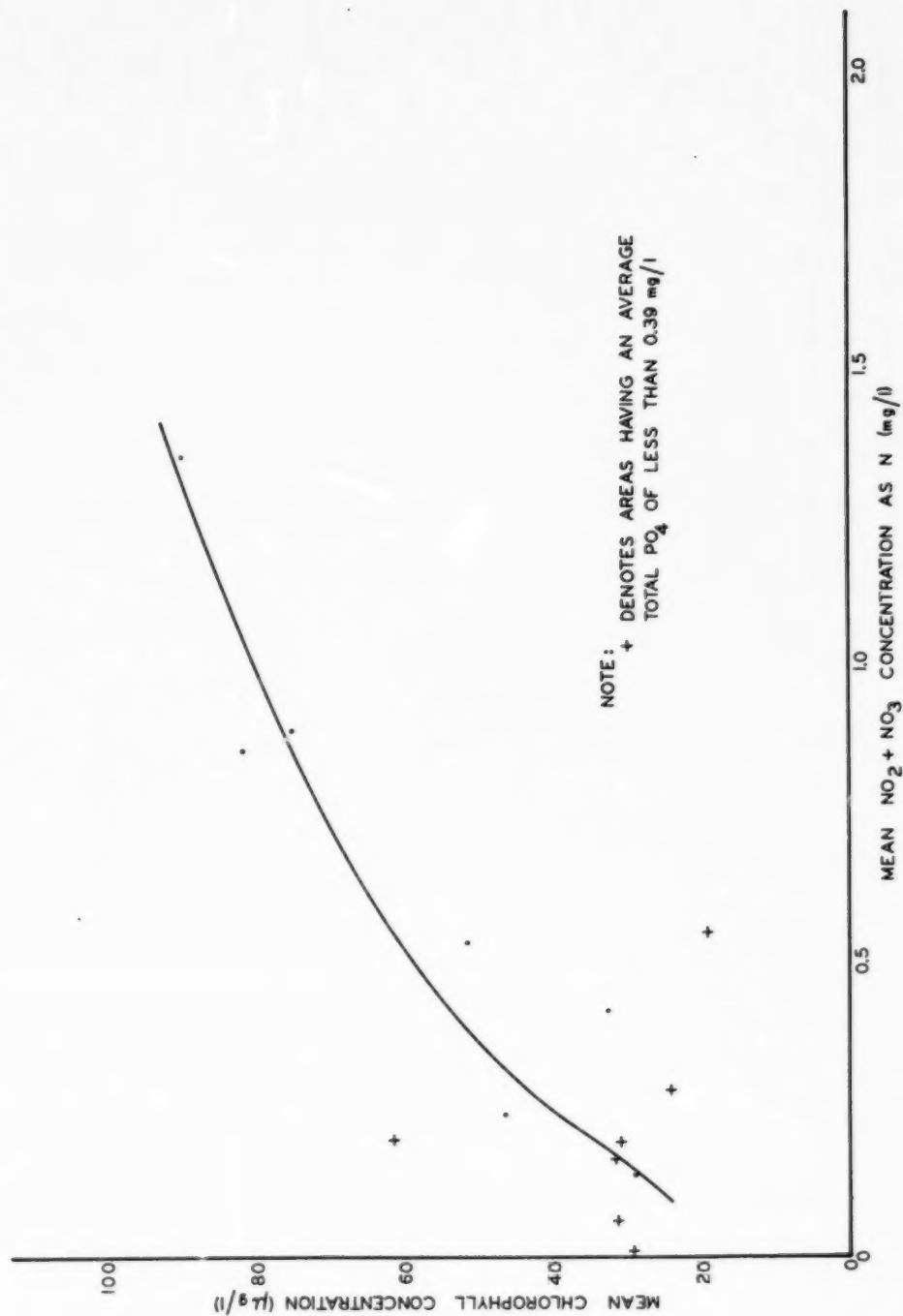


FIGURE III-5

CHLOROPHYLL - INORGANIC NITROGEN CONCENTRATIONS
 POTOMAC ESTUARY
 INTENSIVE SURVEYS - 1966 & 1968

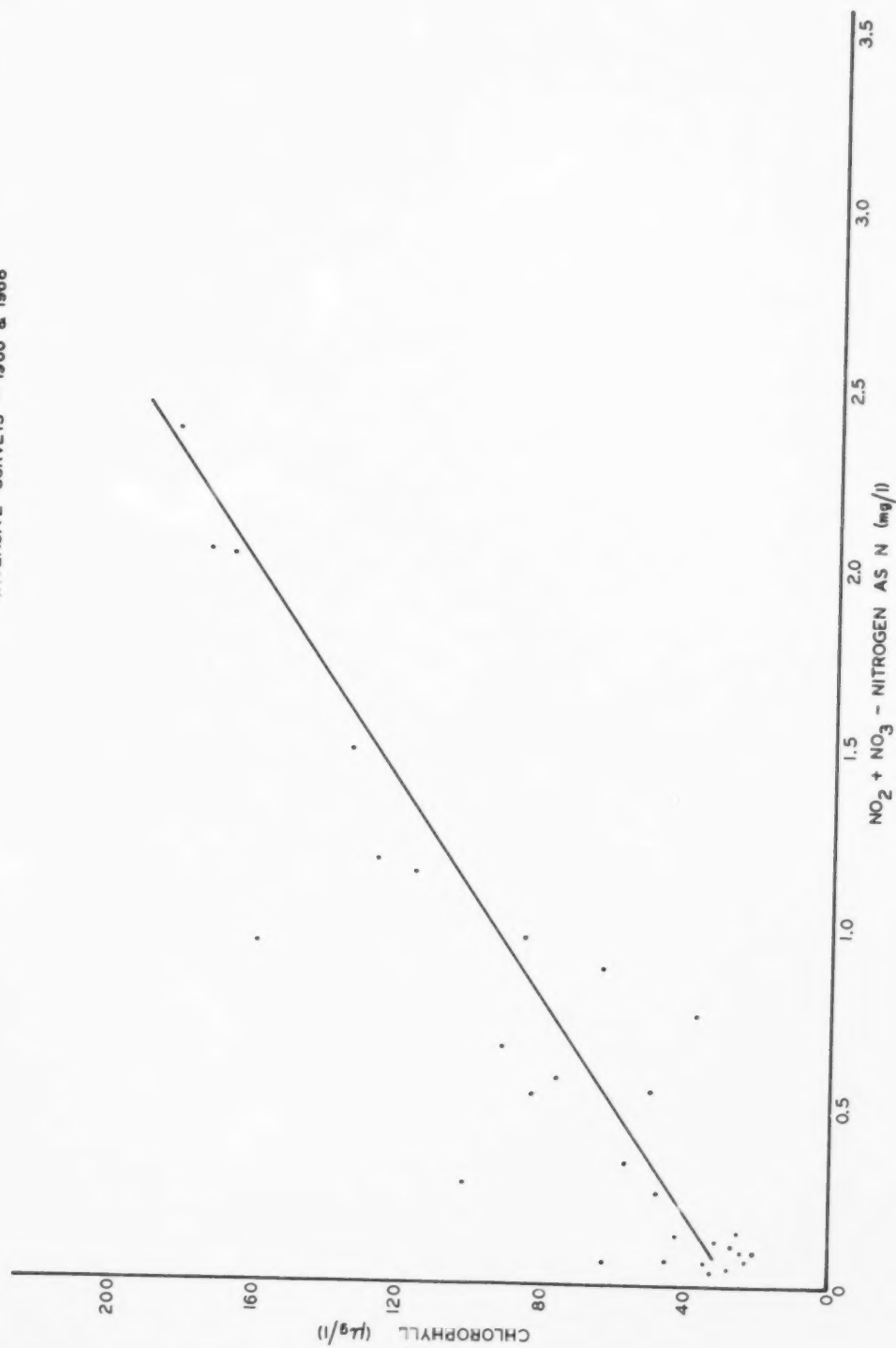


FIGURE III-6

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0.35 mg/l of $\text{NO}_2 + \text{NO}_3$ nitrogen as N should alleviate nuisance phytoplankton conditions in the Potomac Estuary. Again, this is assuming that no other vital system is rate-limiting.

Also, in analyzing the data from the 1965-1968 Potomac Estuary surveys and monitoring stations in the Chesapeake Bay, the following observations have been made:

1. During the periods of low flow in the summer months, high chlorophyll concentrations and high $\text{NO}_2 + \text{NO}_3$ (end product of the oxidation of NH_3) usually occur in the same reach of the upper Potomac Estuary. This suggests that nitrogen could be limiting the total standing crop; however, more studies are needed to determine the significance of this simultaneous occurrence.

2. In the lower part of the estuary, and in the Chesapeake Bay, a significant relationship between TKN and chlorophyll was established for summer conditions. Mass balances in the Potomac Estuary for 1966 and 1968 indicate a continued increase in TKN loading rates in the upper 30 to 40 miles of the estuary.

3. In waters seaward from areas with high chlorophyll levels, nitrate levels are usually

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quite low during the summer months. The low nitrate levels coupled with high TKN concentrations suggest that algal cells are utilizing the nitrate form of nitrogen readily and converting it to TKN.

4. Mass balances from the 1968 Potomac Estuary data obtained in August indicate that from River Mile 15.0 to 40.0 the loading rate for TKN was increased from about 6.0 to over 13.0 lbs. per linear foot. (See Figure III-4.) This suggests that fixation of nitrogen from the atmosphere was significant. If all this TKN was from nitrogen fixation, the amount of nitrogen was about equivalent to that from the wastewater discharge loadings.

C. Other Considerations

1. Stream Flow

In the Potomac and the Patuxent* estuaries, the effect of a large increase in fresh water flow on reducing chlorophyll has been observed on numerous

* The Patuxent River Basin, lying within the State of Maryland, is about one-tenth the size of the Potomac.

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occasions.

Reduction in chlorophyll levels by a sudden increase in stream flow is attributed partially to dilution, dispersion and seaward displacement. In the Patuxent River especially, suspended sediments appeared to remove some of the algal growth by accelerating the settling of the cells.

During September 1966, after the lowest flow of record entering the Potomac Estuary (150 cfs), chlorophyll levels of over 200 $\mu\text{g}/\text{l}$ were reduced to less than 25 $\mu\text{g}/\text{l}$ by a rapid rise in flow to over 27,000 cfs. Similar observations were made in the Patuxent during July of 1968.

2. Temperature, Solar Radiation, and Light Extinction

The effects of temperature and light conditions on algal growth have been well studied in the field and in the laboratory (11) (12).

Average temperatures in the Potomac Estuary for the months of May through October range from 18°C to 28°C. When the temperature as presented in Figure II-1 is compared with chlorophyll "a" as shown in Figure II-8, it can be seen that temperatures above

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20°C appear to be conducive to supporting extensive algal growths in the Potomac Estuary.

Analyses of light intensity data such as turbidity and Secchi disc readings which could affect the algal standing crop have indicated no statistically significant relationship.

3. Other Environmental Parameters

Many other environmental parameters such as heavy metals, salinity, micronutrients, etc., which may have some effect on algal growths are either currently under study or have been incorporated into the 1971-1975 program plan of the Middle Atlantic Region, FWPCA.

CHAPTER IV

ORGANIC LOADINGS IN THE UPPER AND MIDDLE ESTUARIES

The BOD concentrations in the upper estuary as shown in the isopleth in Figure II-4 are greatly increased by wastewater discharges from the Washington metropolitan area. To aid in the design of

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treatment facilities, a study of the magnitude and significance of each of the sources of BOD and other organic loadings as presented in Chapter II was undertaken.

In Figure IV-1, the measured 5-day BOD and TOC concentrations during the intensive survey of August 19 to 22, 1968, are shown. The corresponding nutrient and chlorophyll concentrations are presented in Figure III-2.

The major difficulty in quantitating the significant sources of BOD is that the 5-day BOD determination is a composite of all four sources. The discussion that follows is an attempt to quantitate the various sources of 5-day BOD in the upper and middle estuary.

A. Algal Carbonaceous and Nitrogenous BOD

During the growth phase, phytoplankton have been shown to have considerable diurnal effect on the oxygen balance as a result of photosynthetic oxygen production during the day and the "take-up" of oxygen by respiration at night (13) (14). In algal cells, Bain (15) has computed the theoretical ultimate oxygen

5-DAY BOD DELINEATION & TOC - DO PROFILES

POTOMAC ESTUARY

AUGUST 19-22, 1968

C-RESAPEAKE TECHNICAL SUPPORT LABORATORY

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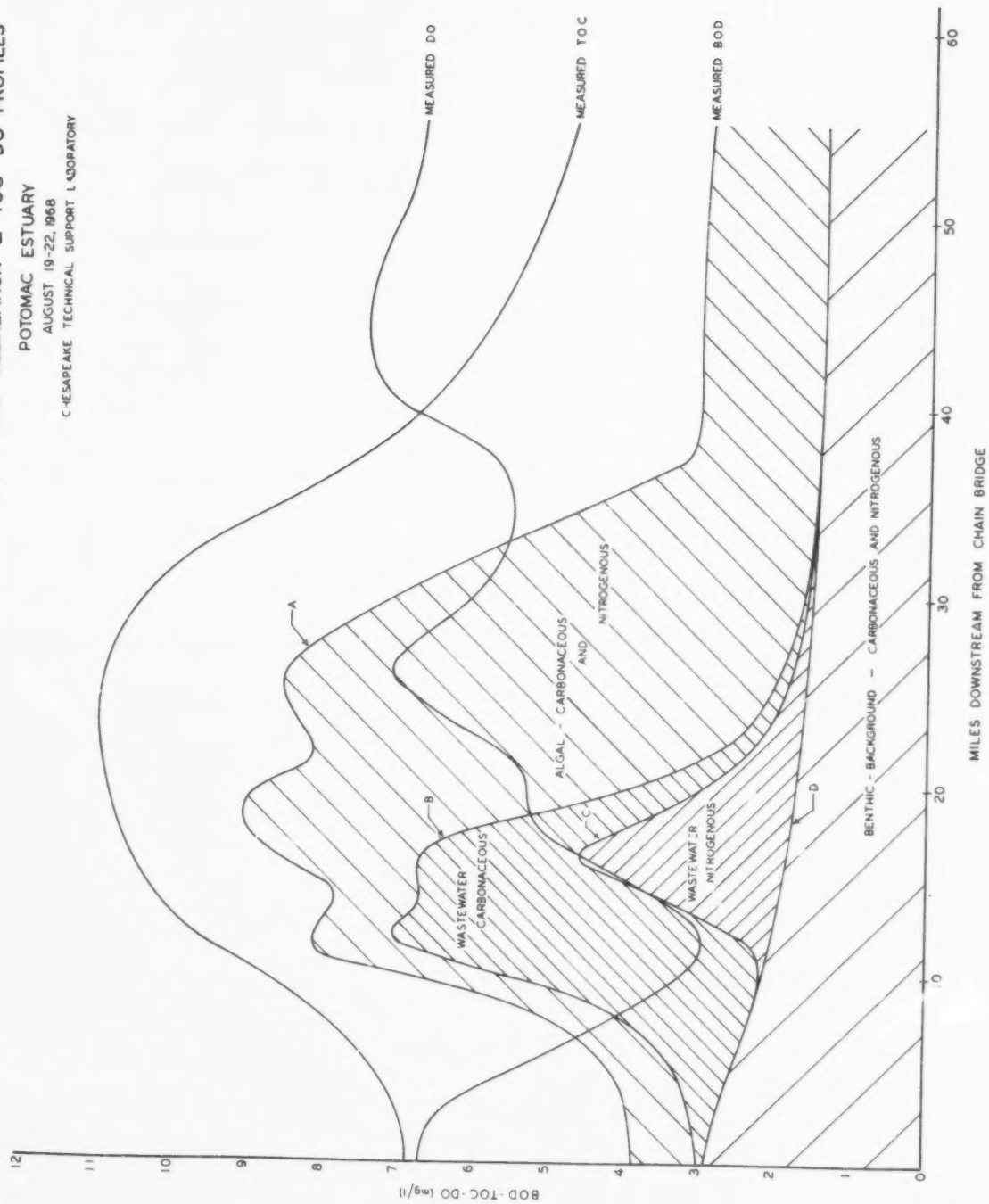


FIGURE IV-1

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demand* of a phytoplankton growth having a concentration of $1.0 \mu\text{g/l}$ of chlorophyll to be about 0.23 mg/l if all carbon and nitrogen were oxidized.

To determine the contribution of the massive phytoplankton growths to BOD in the Potomac Estuary, statistical studies were made on data from sampling stations in the lower Potomac and Chesapeake Bay receiving no significant wastewater discharges. The following relationship was developed for the lower estuary:

$$\text{BOD} = 1.5 + 0.03 \text{ Chloro}$$

where

$$\text{BOD} = \text{5-day BOD at mid-channel depths (mg/l)}$$

$$\text{Chloro} = \text{chlorophyll concentration at the water surface (}\mu\text{g/l)}$$

Further analysis utilizing TOC data indicated that most of the algal contribution to BOD was

* Ultimate oxygen demand (16) consists of the sum of the carbonaceous and nitrogenous BOD as given below:

$$\text{UOD} = 2.67 \text{ C} + 4.57 \text{ N}$$

where

$$\text{C} = \text{unoxidized carbon}$$

$$\text{N} = \text{unoxidized nitrogen}$$

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in the form of carbon. For the lower Potomac Estuary, the following relationship was established for summer conditions:

$$\text{BOD} = 2.0 + 0.68 \text{ TOC}$$

where

BOD = 5-day BOD at mid-channel depth (mg/l)

TOC = total organic carbon at mid-channel
depth (mg/l)

If a chlorophyll level of 100 $\mu\text{g/l}$ is substituted into first relationship, a BOD of 4.5 mg/l is obtained. This is considerably less than the theoretical total oxygen demand which would be 23.3 mg/l. From the above analysis and the TKN load rate curve in Figure III-3, it appears that oxidation of the organic nitrogen component of wastewater and of phytoplankton cells does not occur very rapidly. Similar observations on the slow remineralization of nitrogen compounds from phytoplankton have been made by Gotterman (17) and Harvey (18).

Using the above two relationships, the amount of 5-day BOD attributed to the algal standing crop was determined. The algal BOD was then subtracted from measured 5-day BOD (curve A) as presented in

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Figure IV-1 yielding curve B. The maximum contribution from the standing crop was at River Mile 27.0 where the 5-day BOD was about 6.0 mg/l.

B. Wastewater Carbonaceous BOD

The contribution of 5-day carbonaceous BOD from the wastewater discharges was determined by routing the loadings as presented in Table II-1 in a mathematical model of the upper estuary (4). The fresh water inflow and other model parameters were based on observed conditions during the August 19-22, 1968, survey.

The wastewater carbonaceous BOD contribution was subtracted from curve B to determine curve C in Figure IV-1. With 2770 cfs of fresh water entering the estuary, the maximum increase from wastewater carbonaceous BOD was about 4.5 mg/l at River Mile 11.0.

C. Wastewater Nitrogenous BOD

On an ultimate oxygen demand basis, the nitrogenous BOD can be expressed as follows:

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$$UOD_n = 4.57 N$$

where

UOD_n = ultimate nitrogenous oxygen
demand (mg/l)

N = unoxidized nitrogen (mg/l)

The above expression has been verified
in the laboratory and in the field (19) (20).

The amount of nitrification in the 5-day
BOD usually is considered to be insignificant. Recent
studies by CTSL indicated that in highly nitrified water
such as the Patuxent and Potomac, the oxidization of
 NH_3 in the 5-day BOD determination often begins within
the first three days of the test. Moreover, in
regression analyses of data from the middle and lower
Potomac Estuary, generally free from any wastewater
sources, the following relationship was established:

$$BOD = 1.0 + 3.3 NH_3-N + 0.03 \text{ Chloro}$$

where

BOD_5 = 5-day BOD concentration (mg/l)

NH_3-N = Concentration of NH_3 nitrogen
(mg/l)

Chloro = Chlorophyll concentration ($\mu g/l$)

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The 3.3 constant for $\text{NH}_3\text{-N}$ is somewhat lower than the theoretical value of 4.57. This difference could be due to NH_3 lost to the atmosphere as suggested by Stratton (21).

When the benthic-background BOD, curve D, as presented in the next section, is subtracted from curve C, the amount of the contribution to 5-day BOD from the nitrification process is obtained (Figure IV-1). The largest difference of 2.5 mg/l between the two curves at River Mile 16.0 vividly demonstrates the contribution of the nitrogenous oxygen demand in the 5-day BOD. The effect of nitrification on DO balance is presented later in this chapter.

D. Benthic-Background Carbonaceous and Nitrogenous BOD

Beginning with 2.8 mg/l at River Mile 0.0 and gradually decreasing to 1.5 mg/l at River Mile 55, a benthic-background BOD (curve D) was developed from measured 5-day BOD. This BOD, which can in part be attributed to sludge deposits, upstream loadings, NH_3 loadings from the bottom deposits, etc., is both carbonaceous and nitrogenous. No attempt has been made

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to fraction this source.

E. Ultimate Oxygen Demand Comparison

In Figure IV-1, the delineation of BOD clearly demonstrates "how much and where" each of four major sources contributes to the total 5-day BOD in the upper estuary. A somewhat different perspective of the BOD sources is obtained when the UOD sources for the upper estuary between Chain Bridge and Indian Head (River Mile 29.5) are compared as tabulated below.

<u>Sources</u>	<u>UOD</u> <u>lbs./day)</u>
Wastewater - carbonaceous	188,000
Wastewater - readily oxidizable nitrogenous (NH ₃ -N)	125,000
Wastewater - less readily oxidizable nitrogenous (organic-N)	116,000
Algal-carbonaceous and nitrogenous	400,000*
Benthic-background - carbonaceous and nitrogenous	80,000

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From the above tabulation, it can be readily seen that the major source of UOD in the upper estuary is from phytoplankton with the sum of wastewater nitrogenous BOD second, wastewater carbonaceous BOD third, and benthic-background fourth.

F. Dissolved Oxygen Balance

A schematic diagram in Figure IV-2 originally presented by Torpey (22) shows the interrelationships of the oxidation of carbonaceous and nitrogenous organic matter, photosynthetic activity of phytoplankton, and dissolved oxygen. In the upper Potomac Estuary, these three biological systems can and do occur simultaneously in the same reach: oxidation of wastewater and algal carbon; oxidation of wastewater NH_3 ; and photosynthetic activity.

The predominance of one or all of the

* (Previous page) Based on the amount of 5-day BOD required to increase the BOD 6.0 mg/l in the upper estuary. This value can be considered conservatively low.

A SCHEMATIC DIAGRAM OF
DISSOLVED OXYGEN INTERRELATIONSHIPS
FOR THE THREE
MAJOR BIOLOGICAL SYSTEMS

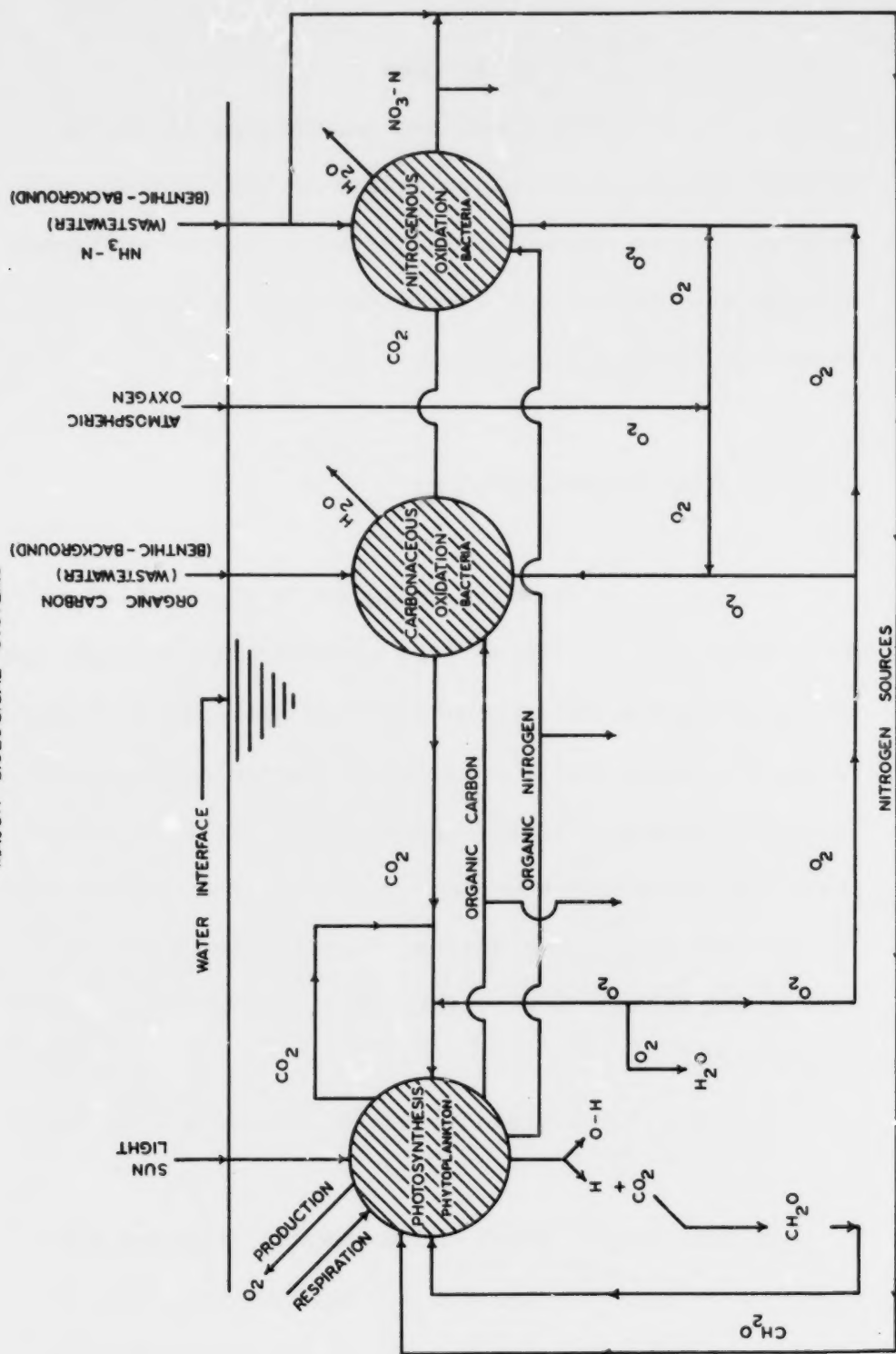


FIGURE IV-2

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three systems depends upon such environmental factors as temperature and fresh water inflow. The variation in the DO isopleths as exhibited in Figure II-3 demonstrates the effects of environmental changes on the three systems.

The DO profile for the intensive survey during August of 1968 has three distinct depressions in the upper estuary corresponding to the three biological systems. The first large depression at River Mile 11.5 was mainly due to the oxidation of wastewater carbonaceous BOD. The second depression at River Mile 20 was caused primarily by oxidation of the wastewater nitrogenous BOD. When compared to the nitrification in either the previous or succeeding two-week period, the DO depression in this reach was considerably less as a result of a 50 percent increase in fresh water flow into the estuary during the intensive survey. This reduction in nitrification can be seen clearly in the $\text{NO}_2 + \text{NO}_3$ isopleth in Figure II-6.

The sharp increase to 71 mg/l near River Mile 26 was probably a result of oxygen production by algal cells which were at their highest concentrations in the estuary at this point.

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In the reach from River Mile 25 to 35, the 1.5 mg/l DO depression is attributed to decay of the algal cells. A secondary recovery in DO towards saturation values begins at River Mile 35.

CHAPTER V

CURRENT AND PROPOSED INVESTIGATIONS

As indicated in Chapters III and IV, the four major areas currently being studied by CTSL in regard to the Potomac Estuary are as follows:

1. Nutrient-algal relationships,
2. Role of nitrification in DO balance,
3. Nutrient transport mechanisms and rates, and
4. Dispersion.

The data and interpretations presented in this report are to provide a basis for current planning of waste treatment facilities to achieve water quality standards. Studies will be more extensively developed in four separate reports covering each of these areas.

G. W. Cook

Three field studies which are to be initiated in the near future are:

1. Rate of algal carbon fixation and oxidation,
2. Nutrient-algal rate limiting studies, and
3. Nutrient exchange rates with sediments.

The four current and three planned studies are all designed to provide data for the development of a comprehensive plan for water quality management for the Potomac Estuary.

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SECRETARY KLEIN: We are at the twelve o'clock mark.

With respect to that last statement about costs, you and I know that the taxpayer will pay for anything and will stand behind any program that he thinks is necessary for his health, his comfort and his welfare.

It has been the task of the Federal Water Pollution Control Administration to bring this home time and time again. It will be the task of all of the conferees who are at this head table to bring it home. Fortunately, for the last several years, and some of them have been on us longer than that, all of the news media have concentrated their efforts on this also, on the need for pollution control.

As a result of the dissemination of information, based upon the fact that we get into problems here and look for answers, the last public information report on this was that more than 50 percent of the people were in favor of pollution control even though it cost them money out of their pocketbook.

I think the public is becoming conscious of it. Until the public becomes conscious of it, I don't think anything can be done, and I think that the greatest

service that this conference and any other conference can do is to make the information available to the news media.

I want to thank the news media in this area, as well as all over the country, for working on this problem.

Let us break for lunch and try to be back here at 1:30 o'clock.

(Whereupon, at 12:00 noon, a luncheon recess was taken until 1:30 p.m.)

AFTERNOON SESSION

1:30 P.M.

SECRETARY KLEIN: May we reconvene the conference, please?

This morning we had a series of presentations from notables and from representatives of the area, and I think we then got into the technical aspects of what is wrong with the Potomac River with Mr. Cook. We had a rather spirited discussion, and I think we were getting to the point of what are the problems and what are the answers.

The best possible way that I know of to develop these is by discussion, by questions and answers and not just the presentation of papers.

I trust that we will be able to continue along that same general guideline for this afternoon, because if we are able to do so, I think we will be able to get some results.

Mr. Jensen, are you ready to proceed?

MR. JENSEN: Yes, Mr. Chairman.

The next report of the Federal Water Pollution Control Administration will be a report by Dr. Leo

Dr. L. J. Hetling

Hetling on the Mathematical Model of the Potomac Estuary.

Dr. Hetling was formerly with the Federal Water Pollution Control Administration in the Middle Atlantic Region. He spent a great deal of time working on this problem with the Potomac. He is now Research Director for the New York State Water Pollution Control Program.

Dr. Hetling.

STATEMENT BY

DR. LEO J. HETLING

SPECIAL CONSULTANT

DR. HETLING: I will be speaking from Technical Report No. 7 published by the Federal Water Pollution Control Administration, and which I think is available for the conferees.

SECRETARY KLEIN: Would you please talk into the microphone so everybody hears you?

DR. HETLING: This (indicating) is the report I am speaking from.

This morning everyone said we would defer until the technicians and the engineers who will come on later. I'm the engineer, so I'm stuck.

I would like to talk a little about a

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mathematical model of the Potomac River, and hopefully not scare away a lot of people who are afraid of math. I would like to hopefully give some insight to the ways the model was developed, the way it was verified, and the way it will interact with the people who really make the decisions on the Potomac River.

A systems analysis approach has been undertaken by the Federal Water Pollution Control Administration (FWPCA) in investigating the water quality responses in the Potomac River Basin (1). The analyses included the effects of low flow augmentation, wastewater diversions, water supply withdrawals, and increased degrees of wastewater treatment on water quality in the upper estuary.

Several techniques or mathematical models* capable of simulating the response of water quality in an estuary were available when the study of the Potomac Estuary was undertaken in 1965. After an investigation of the modeling systems available, the segmented estuary model developed by Dr. Robert Thomann (2) was selected as the one which most closely conformed to the requirements of the study.

* A key element in any systems study is a model capable of describing or simulating the system of interest.

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The segmented model is highly flexible and capable of being utilized to describe almost any pollutant. Its accuracy is adequate for engineering design purposes. Properly programmed, the digital computer makes possible solutions of the systems available in minutes at a relatively small cost.

THE MODEL

In order to give the non-engineers among you some idea of what a mathematical model is, I would like to quote from a description of models I previously prepared (3):

"Anyone who has a checking account works with a mathematical model. All deposits are positives and all withdrawals are negatives. Monthly service charges and a charge per check further completes the model. Using technical jargon, we can say that the model has a lower limit (or bound - using the correct mathematical term) in that a negative balance cannot, in theory, exist. With a knowledge of all the inputs (deposits and withdrawals), the initial conditions (original balance) and other sources and sinks (service charges), it is possible

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to compute the balance at any time (a transient model).

"In the same way, by proper bookkeeping and a knowledge of bounds or limits, inputs, initial condition, sources and sinks, it is possible to develop a set of equations which describe water quality in the estuary. The number of computations, of course, in this system when compared with a checking account is enormous. To solve such a system would require many man-years. But, luckily, most of the computations are routine addition, subtraction, and multiplication. Within recent years, digital computers have been developed which can do such routine computations in a fraction of a second. Properly instructed (programmed), the digital computer makes possible solutions of the system available in minutes.

"A key step in the development of any model is its verification; i.e., to check and see if the model truly simulates water quality. This involves a comparison of measured or observed values with computed values.

"A checking account is verified every so often when a statement is received from the bank. When we compare the balance in our checkbook with

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the balance on the bank statement, we find time after time that we have made a mistake. More often than not, it is a blunder; an input (deposit or withdrawal) was forgotten, the bank service charge was changed, or perhaps even the bank made a mistake."

This doesn't happen very often.

In a more technical sense, the mathematical model for the Potomac Estuary was constructed by dividing the estuary into a finite number of discrete segments as shown in Figure 1.

This is shown here on the slide. The segments were made rather small (approximately two miles in length) near the critical portion of the estuary where the rate of changes of water quality is greater and longer in the lower sections where there are small changes in water quality. The assumption is made that the water quality in each segment is homogeneous if the segments are properly selected, and if they are made small enough, this is a proper assumption.

For each water quality parameter we started by writing the equations utilizing all the factors which we felt would affect the given water quality parameter. The upper Potomac Estuary model for a non-conservative

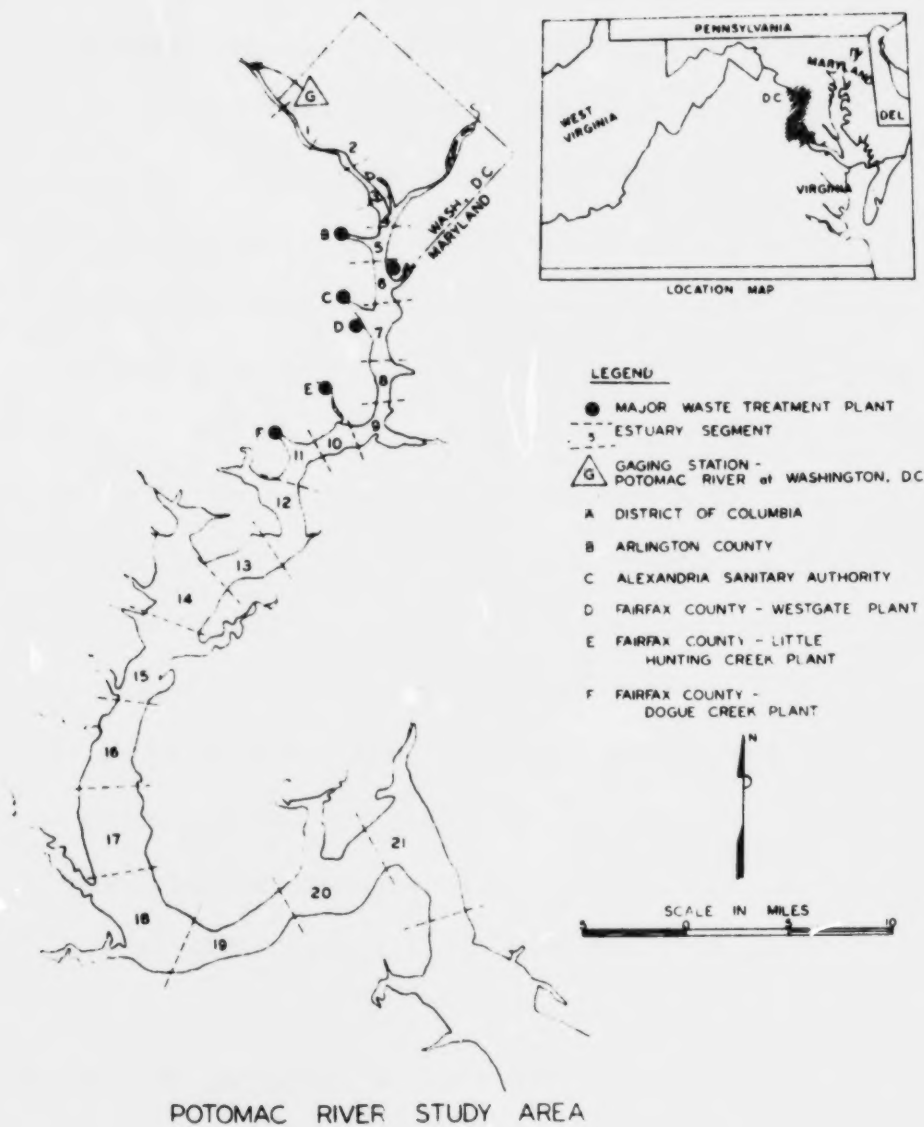


Figure 1

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pollutant such as a biochemical oxygen demand (BOD) consists of a system of 21 equations, each describing a mass BOD balance for the 21 segments of the estuary.

The mass balance over each of the 21 segments shown in Figure 1 includes terms describing changes in BOD concentration caused by advection, dispersion, decay and BOD added by the various sources.

SECRETARY KLEIN: Would you give us those four items very slowly, please, because I think they are the important ones?

DR. HETLING: All right. The actual water quality in each segment is changed with time by advection of fresh water flow from the river into the estuary which pushes BOD out of one segment into the segment below. It changes by tidal diffusion, by moving the BOD in and out, by dispersion, which is more of a molecular dispersion, which might happen by some transient force, and also BOD decay rate. If we put it there the organic matter decays and turns to an oxidized material. And then we have the actual BOD load added by the various sources, whether it be a waste treatment plant effluent, industrial waste, or land runoff.

Continuing, the system of 21 linear first

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order, non-homogeneous, ordinary differential equations which describes the changes is then solved simultaneously by numerical methods using a digital computer.

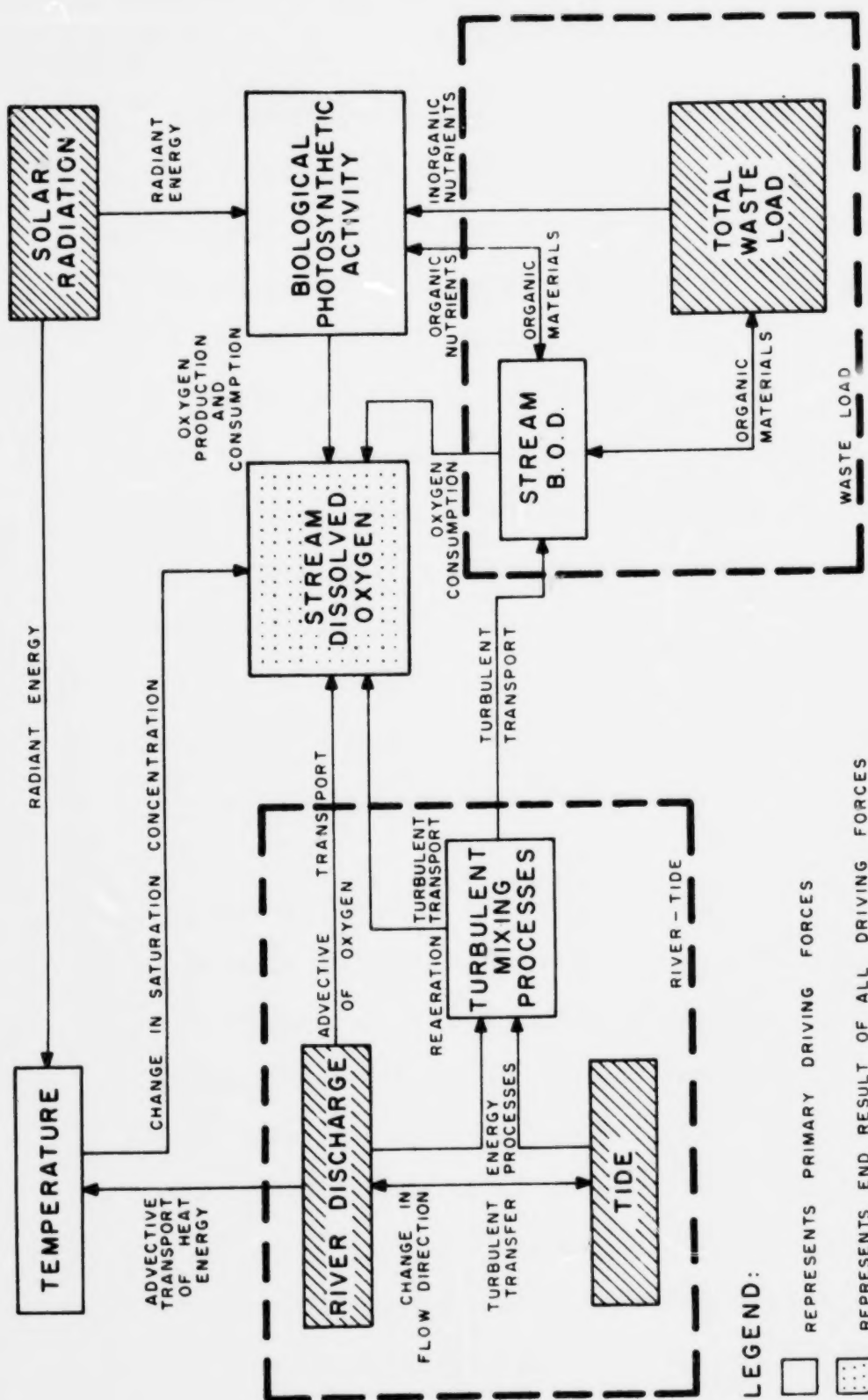
Dissolved oxygen (DO) is probably one of the most important parameters to know when talking about the water quality of the estuary. It is also the most difficult to model, since DO can enter or leave the estuary in so many different ways. Figure 2 will give you an idea of the system which affects DO concentration in an estuary. Factors such as benthic uptake of oxygen, nitrification, and photosynthesis further complicate the DO balance in the Potomac Estuary.

For simulating the DO in the upper estuary, the model consists of 42 equations, 21 describing a mass balance for the ultimate oxygen demand (UOD) and 21 equations for the dissolved oxygen. Vertical and lateral homogeneity in each segment are assumed.

MODEL VERIFICATION USING DYE STUDIES

I would like to describe a large-scale study which was carried out to verify the model in order to give you a better feel for its capabilities (4).

Most natural water quality parameters are



FACTORS AFFECTING STREAM DISSOLVED OXYGEN CONCENTRATION

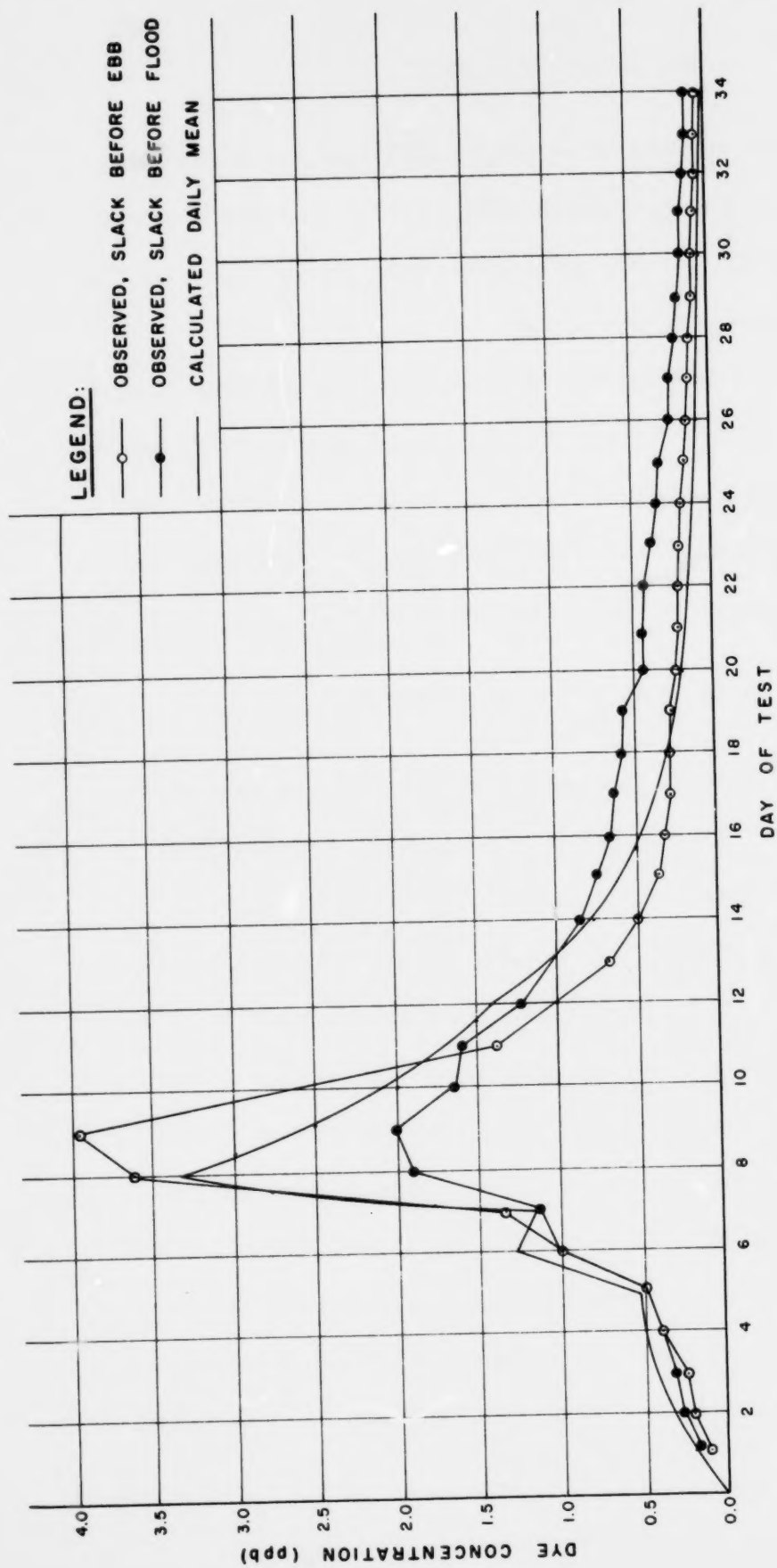
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involved in so many complex chemical, biochemical, and physical reactions that they do not lend themselves to a good simple test of the model. Therefore, our first attempt at verification was a dye diffusion study. We injected a semi-conservative dye (Rhodamine WT) into the estuary through the effluent pipes of the District of Columbia's Water Pollution Control Plant at a known rate. See Figure 1 for the location of the wastewater treatment plant.

Figure 3 shows the resulting average dye concentration in the estuary measured opposite the plant outfall. The solid center line shows the concentration of dye predicted by the model, while the other two lines represent the actual measured concentrations at high and low tide.

The matching of the observed data and calculated data did not, of course, occur on our first try with the initial model coefficients. Many repetitive runs of the model were required to get the match you see here. For each repetitive run, a change in a coefficient was made in order to bring the predictive concentrations closer to the measured values.

The close agreement between the measured and calculated dye concentrations found in the above study



POTOMAC ESTUARY
OBSERVED AND CALCULATED DYE CONCENTRATIONS vs TIME

Dr. L. J. Hetling

shows that the segmented estuary model can satisfactorily describe water quality which will result from the introduction of a simple soluble pollutant into the estuary if the correct coefficients are known.

In contrast to the thinking of many people, mathematical models do not relieve the engineer from making assumptions and decisions; what it does do is force him to test the validity of these assumptions by comparing their compatibility with actual measured results.

WATER QUALITY MODELING RESULTS

Now for some germane water quality parameters, I would like to show our results in predicting chlorides and dissolved oxygen.

Chlorides

Chlorides enter the estuary mainly by diffusion upstream from the Chesapeake Bay. The rate of diffusion and extent of intrusion depends primarily on the tidal currents and river flow. Figure 4 shows the observed and calculated variation in chlorides in the estuary at Possum Point near Quantico, Virginia. In the figure you can see that the concentration of chlorides decreased dramatically during the late winter and spring

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months when the river flow was high and increased in the late fall and early winter when the river flow was low.

The chloride concentrations were also used as a natural tracer in establishing the dispersion coefficients for the portions of the estuary not within the 1965 dye release as previously described (5). In Figure 5, the dispersion coefficients are presented as determined by the dye studies and from a study of the chloride intrusion. Thus, the model can be used to predict both a given water quality parameter and to establish model coefficients which can be utilized for modeling other water quality parameters such as DO.

Dissolved Oxygen

Our results in modeling DO have been very encouraging even though there are many factors affecting the dissolved oxygen in an estuary as indicated previously (3). The capability of the model to predict the effects of the addition of wastewater loadings on DO in the Potomac Estuary can readily be seen when Figures 6 and 7 are compared.

Presented in Figure 6 is the observed and predicted DO concentration for the Potomac Estuary in 1965 near Memorial Bridge which is upstream from the major waste-

POTOMAC ESTUARY CHLORIDE MODEL

1965 CHLORIDES at POSSUM POINT

MEASURED VALUES

CALCULATED BY MODEL

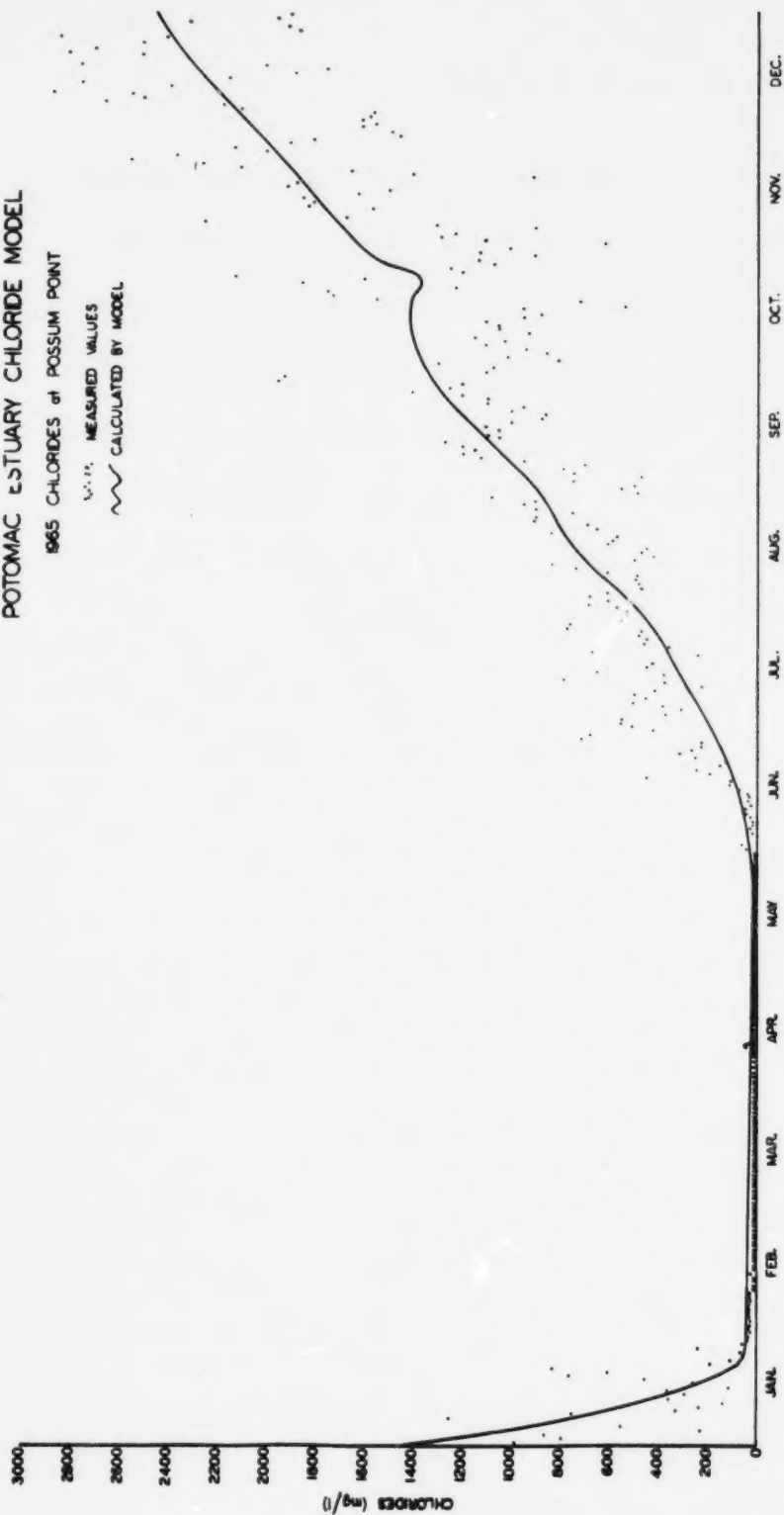


Figure 4

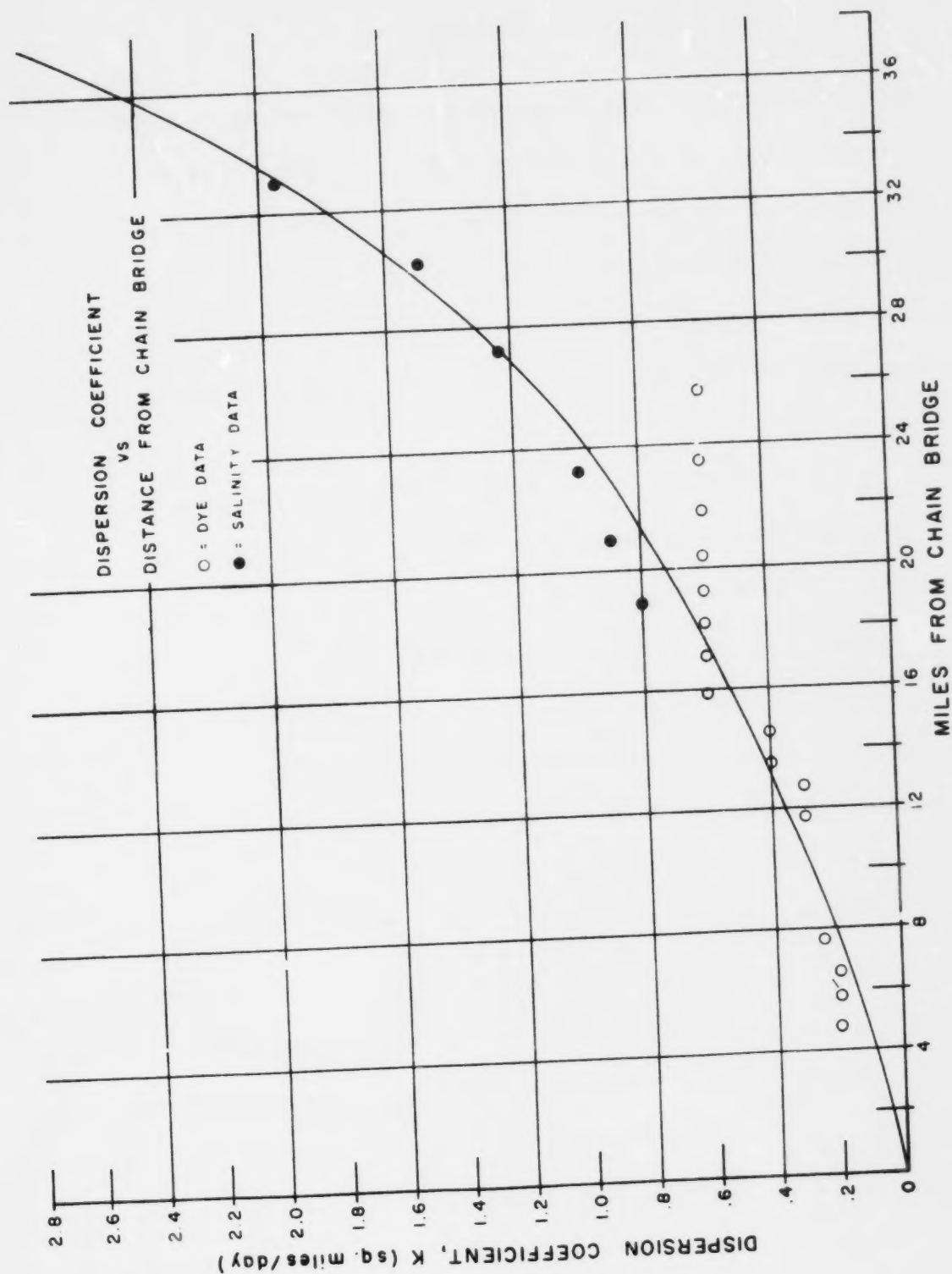


Figure 5

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water discharges. The observed and predicted average DO for the summer months is about 6 mg/l. Figure 7 shows the observed and predicted DO in the estuary in 1965 at Woodrow Wilson Memorial Bridge which is within the tidal excursion range of the major discharges. The observed and predicted average DO for the summer months is about 2.0 mg/l.

During the summer months, if you go a few miles upstream from the waste effluent, a more critical point, we have a minimum DO of about 6 parts per million, a minimum average. Here is lower down the estuary. This is at the Woodrow Wilson discharge, and here it dropped down to less than 2 parts per million. Here again is the maximum between the dots. The actual observed values between the computer predicted values, the dots, and solid lines is fairly close.

It should be noted that only average concentrations are obtained from the output of the model. The "to and fro" oscillations caused by tidal movement and diurnal fluctuations as a result of phytoplankton activity can create significant variations from the mean predicted concentrations. Nevertheless, the ability to predict the average daily concentration of DO (normally used in design)

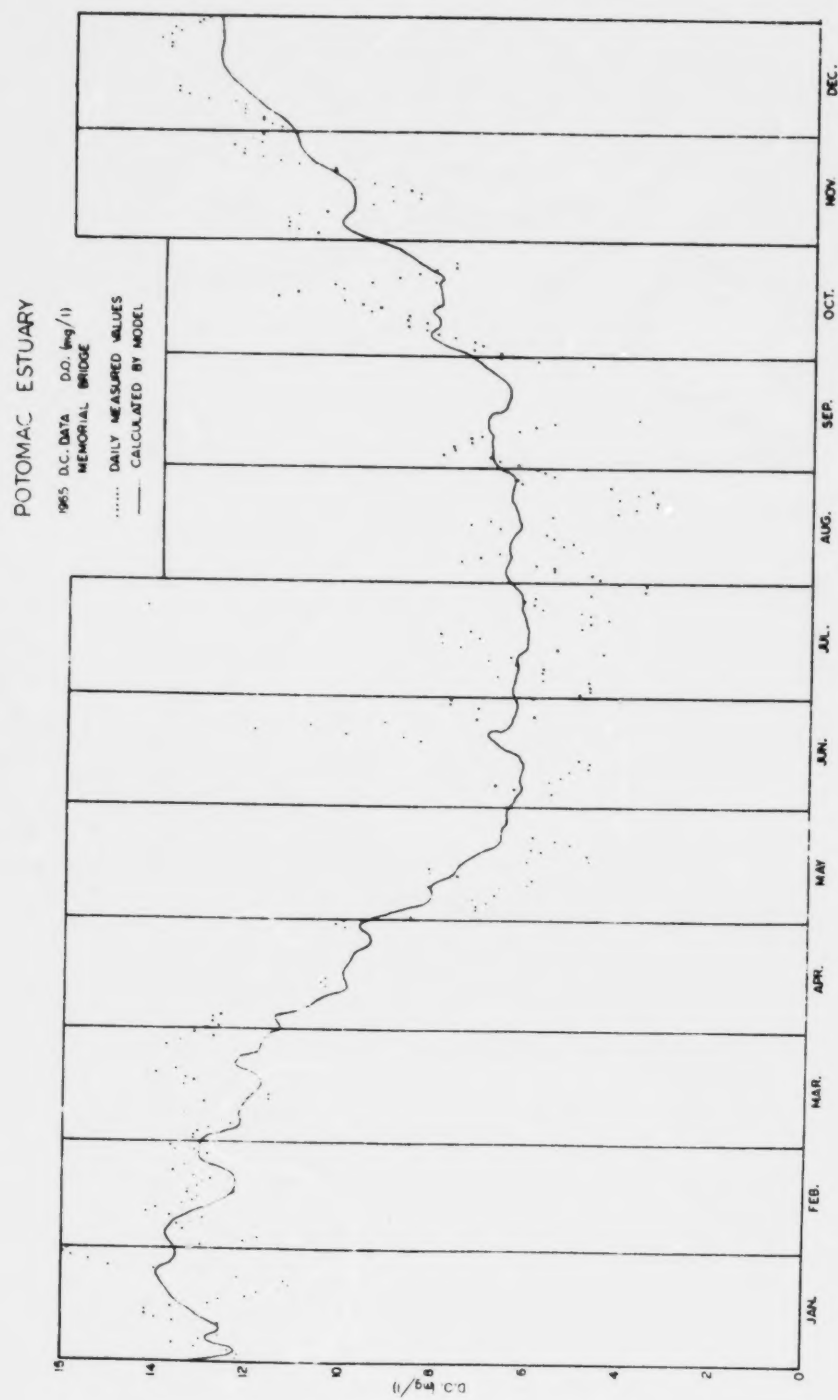


Figure 6

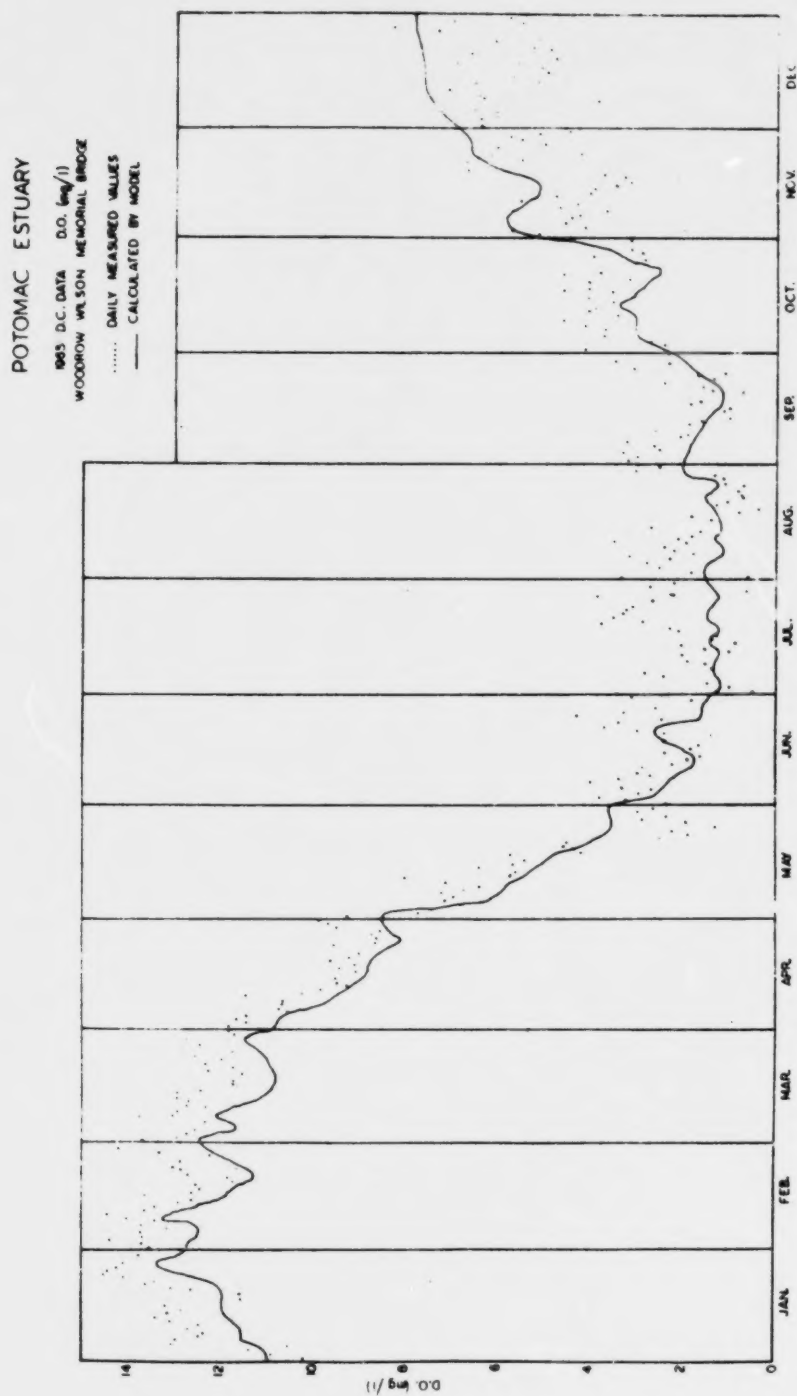


Figure 7

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has been adequately demonstrated.

USES OF THE POTOMAC ESTUARY MODEL

I think that following this somewhat technical description of the model, it might be helpful to discuss the uses made of the model for the Potomac Estuary and thus get a feel for how models and people interact.

Up to the present time, the model described has been utilized in a variety of ways in the Potomac Estuary water quality management process as summarized below:

1. In its studies to determine a range of feasible alternative plans to improve water quality in the estuary, the Water Quality Sub-Task Force of President Johnson's "Project Potomac" (6) made extensive use of the model.
2. Results from the model were used by Dr. Robert Davis, of Resources For the Future, in his study of the effects of advances in technological software on the planning process. Dr. Davis recently published a book entitled "The Range of Choice in Water Resources Management: A Study of the Potomac Estuary" which resulted from this application.
3. The model has been utilized to determine

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the feasibility of using the upper estuary as a future emergency water supply for the Washington Metropolitan Area (8). On the basis of salinity considerations only, this has been shown to be a feasible alternative. The economics and aesthetics of such a program have not yet been investigated.

4. It has been used at the request of States to assist in developing their long-range water quality control plans.

5. It is continuously utilized by FWPCA as a tool for planning for and analyzing the results of field studies. In this way, it has proven extremely valuable in development work in such areas as nitrification, nutrient transport and algal control. The results of these studies are, in turn, put back into the model in the form of better estimations of the model coefficients and thus improve its predictive capabilities.

6. Finally, the model has been utilized in determining the degree of treatment required by the waste treatment plants discharging into the Potomac Estuary to meet the water quality standards adopted by the District of Columbia and the State of Maryland. These results have been presented to the conference by FWPCA as recommendations.

Dr. L. J. Hetling

Thank you.

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* * * * *

SECRETARY KLEIN: Now, if you will make yourself available for questions, please, we will try to get this scientific dissertation down to the point all the rest of us understand it.

The conferees on my left, any questions?

MR. SINGLETON: I have no questions.

MR. PAESSLER: No questions.

SECRETARY KLEIN: On my right?

MR. McKEWEN: I have just one.

Dr. L. J. Hetling

Dr. Hetling, in the inputs, did you include the dissolved oxygen in sewage plant discharges?

DR. HETLING: We made an assumption that there would be 4 parts per million of dissolved oxygen in the discharge, in the effluent, which seems reasonable if one goes through the degrees of advanced waste treatment that are required.

MR. McKEWEN: Would it make much of a significant difference if the DO went up from 4 to, say, 6?

DR. HETLING: Probably if you said "4 to 5," I would say no. If you say "4 to 6," it might. I mean it might be lower by half a degree or a degree, or something.

MR. McKEWEN: Thank you.

SECRETARY KLEIN: I have a number of questions. Let's see if we can resolve this down to where we all understand it.

Number 1. You are comparing observed values with computed values. According to the charts we saw up there, the observed values and the computed values came out pretty close?

DR. HETLING: Yes, sir.

SECRETARY KLEIN: How far does this mathematical model go for other systems, other river basins,

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such as the Hudson, Buffalo, Chicago, and what have you?

DR. HETLING: There is one very similar on the Delaware River system which worked out quite well.

SECRETARY KLEIN: In other words, they started it and you were able to change it over to here?

DR. HETLING: Right. We took the same basic model and converted it. The same thing is now being done on the Hudson River by the engineering firm of Whitlow & McCluskey.

SECRETARY KLEIN: To go a little bit further, are you sure that you picked up all the possible factors that were involved which are necessary to be considered in water quality and pollution?

DR. HETLING: I don't quite follow you.

SECRETARY KLEIN: Well, you must have had a number of other items besides just these four that you gave us.

DR. HETLING: Oh. We ran the model and got valid results, verified results, with chlorides.

SECRETARY KLEIN: In other words --

DR. HETLING: And phosphorus, and bacteria.

SECRETARY KLEIN: And the actual observation on the river is approximately the same as the model?

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DR. HETLING: Right. It was done on phosphorus, ammonia, nitrification, dissolved oxygen, MPN and chloride.

SECRETARY KLEIN: In other words, you proved out the 1958 figures that we had, and the 1965-1966 figures?

DR. HETLING: Yes, sir.

SECRETARY KLEIN: By use of this mathematical model?

DR. HETLING: Yes, sir.

SECRETARY KLEIN: And when you were talking about benthal, that is the stuff at the bottom which doesn't hold an anchor?

DR. HETLING: Right.

SECRETARY KLEIN: And what you were talking about on chlorides is when we don't have any flow in the river, that the Chesapeake waters which are brackish back up into the river?

DR. HETLING: Back up, right.

SECRETARY KLEIN: I think that kind of clears that up a little bit so that we get an idea. But the main idea is that you were able to get all of these different factors in at the proper weighted levels so that you came out with proper figuring?

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DR. HETLING: Right. It seemed valid from an engineering point of view.

SECRETARY KLEIN: Thank you.

MR. JACKSON: Mr. Chairman, may I raise a question?

SECRETARY KLEIN: Yes, Mr. Jackson.

MR. JACKSON: How did you account for stormwater runoff in your mathematical model?

DR. HETLING: If one calculates the actual percentage of BOD's that are from stormwater runoff over a two week period or a month period, the estuary response time is about a month and not hours or days, and it is such a small percentage of the load going in from the waste treatment plant that we can neglect it, because you are talking about a 1 percent area.

MR. JACKSON: Is this what is considered the polluting stormwater as well?

DR. HETLING: This is the BOD.

MR. JACKSON: But BOD isn't a polluter.

DR. HETLING: It is, by my definition.

MR. JACKSON: All right, we'll let it go at that.

SECRETARY KLEIN: I would agree with Mr.

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Jackson. It is not necessarily, it could be, and just being able to compute it I think may be helpful, Mr. Jackson. I don't know whether it is the final answer anyway.

DR. HETLING: No, but there is really a small percentage of BOD that comes from the stormwater overflows over a month's period. There may be a big shot for one day, but if you average it over a month it is a small percentage and not significant in the calculations of the type we are doing.

SECRETARY KLEIN: I might give you my conclusion at the end of this, in listening to it, that I think the greatest difficulty we have had to date--and this is where we are going to have to change our technique--is we don't know what we've got and what the problems are specifically. We have been guessing in the past by what is on shore and what comes in from the shore, but we have not been able to catalogue them.

I think I made this point with Mr. Muskie--that we've got to catalogue them. The anti-degradation statement is fine, but until you catalogue the problems, you don't know where you are at, and with the mathematical model such as Dr. Hetling has been talking about, we then can get to the actual cataloguing of the problem and find

out what the answers should really be, and to that end I think it will do some good.

Mr. Jackson.

MR. JACKSON: Mr. Chairman, I have a question.

Did you give the same consideration that you gave to stormwater also to combined sewer overflows, and isn't that a consideration as well?

DR. HETLING: In the District of Columbia, because we are talking about combined sewers, I assumed your original question referred to combined sewer overflows and not stormwater.

MR. JACKSON: You are saying that pollutants from combined sewer overflows are really minimal and of not considerable consequence?

DR. HETLING: I say BOD and nutrients. I say MPN's, bacteria, are significant, oils are obviously significant, and debris is significant. These are things that were not calculated in the model.

MR. JACKSON: Then back to our BOD measure of pollution again, would you say, using that measure, that stormwater overflow or combined sewer overflow is of minimal consideration?

Dr. L. J. Hetling

DR. HETLING: Right, I would say that.

MR. JACKSON: Thank you, Mr. Chairman.

SECRETARY KLEIN: On that point, you know, I keep going back to separated sewer systems to find out what we have, and you and I know that cities like Washington, Chicago and the like can't tear up all their streets and replace combined sewers with storm and sanitary sewers.

I would like to let you know that Allis Chalmers is now testing an item that can be dropped into a combined sewer and pick up the flood waters and clean it up when it is going through it. We hope the system works. It is now in the process of operational tests in Milwaukee.

MR. STEIN: Mr. Chairman, I would like to make a statement.

With all these mathematical models, I think we have to recognize that we are making assumptions. In these assumptions, as Mr. Jackson has pointed out by his questions, you can either give credence to the pollution effect of the combined sewers or not. But the question of whether you are dealing with a significant effect over a monthly basis or not may or may not be relevant

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when you are dealing with swimming, say in July or August, when you get a big rush of the flow of the combined sewers which is untreated for two or three days and you hope to open the river for water contact sports.

We have had these same problems in Chicago, New York and Washington. If we are talking about such things as the usefulness of the mathematical model, providing we all recognize the usefulness of it, when we deal with a hard factual situation, we are never going to open one of these metropolitan areas fully to water-contact sports unless we do something about the combined sewers. Neither will we open a metropolitan area unless we know that when that moment of impact comes, people are going to be reasonably safe if they are using these waters, regardless of what happens to these waters, and whether we evaluate them on a monthly or a quarterly basis. The limitations of the mathematical model should be realized.

DR. HETLING: If you talk about bacterial pollution, my answer would be "Yes." The stormwater does have a tremendous effect on bacterial pollution.

MR. PAESSLER: Mr. Chairman, I have a comment to make here.

Dr. L. J. Hetling

SECRETARY KLEIN: Yes?

MR. PAESSLER: Well, I think I certainly agree that stormwater has a transitory effect on an estuary. Nevertheless, the impact of a rush of several inches of stormwater on an estuary can actually knock out completely the dissolved oxygen as well as cause bacterial degradation; so you are not saying that the stormwater in the metropolitan area has no effect on the estuary, are you?

DR. HETLING: No. I am saying it has a tremendous effect on bacterial and it has a tremendous effect on debris, which is significant, oil, unsightliness. It will not affect the DO significantly over a week's period, an average DO.

MR. PAESSLER: I will agree with that, but I think that if studies are made during a storm or shortly after a storm, you can find that there is a tremendous effect on the dissolved oxygen.

I have seen this in at least one other estuary, that the dissolved oxygen actually dropped practically to zero after a storm, and I don't know whether this happens here or not.

DR. HETLING: The data I have seen indicates

not on the monitors.

SECRETARY KLEIN: Any further questions of Dr. Hetling?

(There was no response.)

SECRETARY KLEIN: Thank you.

Mr. Jensen?

MR. JENSEN: Mr. Chairman, the next segment of the Federal Water Pollution Control Administration position will be presented by Dr. A. F. Bartsch.

Dr. Bartsch will speak on the problems of algae in rivers, lakes and estuaries -- and it is sort of a general type of problem that the Nation faces. Dr. Bartsch is from the FWPCA Pacific Northwest Water Laboratory at Corvallis, Oregon, and he is Director of our national research programs on algae.

Dr. Bartsch, if you can summarize your remarks in the interests of time?

STATEMENT OF

DR. A. F. BARTSCH

DIRECTOR, PACIFIC NORTHWEST WATER LABORATORY
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
CORVALLIS, OREGON

DR. BARTSCH: Thank you, Mr. Jensen.

Dr. A. F. Bartsch

Mr. Chairman, Conferees, Ladies and Gentlemen:

I am Director of the Pacific Northwest Water Laboratory, of the Federal Water Pollution Control Administration, in Corvallis, Oregon. I am also Chief of the National Eutrophication Research Program of that agency.

Introduction

In scientific circles the word "eutrophication" is applied most commonly to changes that occur in lakes as a result of increasing the input of plant nutrients or fertilizers. A most important response is the water's increase in the capability to grow large crops of algae and other water plants. Considerable attention has been given to the fact that many of the 100,000 small lakes in the United States already have become involved in this affliction. The symptoms are showing. Afflicted lake waters become green, they stink and are unfit for body recreation and many other uses. This is what we called "dog days" when I was a small boy in Wisconsin. It was a period of no fun during the year because swimming was either prohibited by parents or unattractive even to small boys. Such symptoms are now evident in many lakes in the northern half of the country. The deterioration process started some 12,000

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years ago -- from the very moment that the original 15 lakes came into being as a result of the continental glaciation which brought these initially pristine lakes into existence. Without people, eutrophication processes moved slowly, and change took a long time. The speed varied among different lakes. But with increasing populations, urbanization, and other cultural developments, things that people do accelerate eutrophication. As a result, the utility of the water resources then diminishes more quickly.

I expect we are all aware of the problems in Lake Erie and Lake Michigan; the Madison, Wisconsin, lakes; lakes at Seattle; and in Klamath Lake in Oregon. Many other afflicted lakes could be named. But we are only now beginning to pay real attention to similar problems in estuaries. Some scientists may question that our terminology is correct -- that true eutrophication develops in estuaries such as the Upper Potomac Estuary. From a practical point of view, this really is not important. The Potomac River in the Washington, D. C. Metropolitan Area and downstream already portrays the most detestable symptom of eutrophication -- excessive growths or blooms of unwanted algae. It is this aspect of the water pollution problem toward which I wish to direct my comments. In doing

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so, I want to submit the following important points for your consideration:

First, symptoms of eutrophication in the form of excessive growths of algae are now present in the estuary area under consideration.

Second, the Potomac River water entering the Washington, D. C. Metropolitan Area of the river system already is well supplied with nutrients.

Third, these nutrient supplies are augmented tremendously by wastewater discharges in the Washington, D. C. Metropolitan Area.

Fourth, such nutrient additions stimulate increased production of unwanted algae.

Fifth, treatment of the Metropolitan Area's wastewaters to remove nutrients is the only potentially effective remedial approach now available to decrease production of algae. And --

Sixth, to decrease algal production to an acceptably low level will require, in addition, an effective nutrient control program in the Potomac River Basin upstream from the Washington, D. C. Metropolitan Area.

I will now discuss each of these points briefly in order.

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Symptoms of Eutrophication Are Now Present

Blooms of algae are not new to the Potomac River Estuary. In 1951, I had the opportunity to participate in a brief survey in this area, sponsored, as I recall, by the Interstate Commission on the Potomac River. I can still remember distinctly the dense populations of blue-green algae present at that time downstream from the D. C. area, especially in Gunston Cove. For many years the estuary has been capable of producing substantial quantities of plant material. From a historical point of view, it is interesting to go back and read a report of a 1913 survey by the late W. C. Purdy, of the U. S. Public Health Service, in which he colorfully referred to the substantial weed beds on the estuary tide flats as a tremendous pair of lungs. In this simile, during the rise and fall of the tide, they injected large quantities of needed oxygen into the estuary water. Many changes have occurred since 1913. The rooted vegetation has disappeared, and the algae have increased tremendously. While I do not have exact figures -- and I presume only estimated projections could be made from 1913 -- inputs of nutrients undoubtedly have increased many-fold during this subsequent period.

This may be an appropriate point to explore

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with you some of the pertinent fundamental biology as a means of placing the Upper Potomac Estuary problem and the potential remedy in a suitable context. As Mr. Cook pointed out this morning, algae are plants and therefore require essentially the same nutrients as crop plants. If one examines this need, it soon becomes apparent that the fertility of the water is a complex and vital issue. And the fertility is also a thin, watery mixture involving some ten major chemical elements, needed in substantial amounts, and some six or seven others, needed in exceedingly minute amounts. The farmer has known down through the centuries that the size of the crop he can produce depends directly on the amount of nutrients contained in the soil. When there were deficiencies, he corrected them -- with help of the honey bucket in the Orient, with fishes in each hill of corn in the ancient American Indian's garden, or nowadays with commercial fertilizer. Conditions in the aquatic environment are similar. It has been observed repeatedly in many lakes in the world, also, that the size of the algal crop frequently is determined by the availability of phosphorus or nitrogen, or both.

Here, also, as so often happens with problems of this kind, Man has failed to take advantage over

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the years of knowledge already at hand. It was known 130 years ago, through the studies of a scientist whose name was Liebig, that the size of the crop can be diminished by withholding vital nutrients. When one applies this knowledge to various bodies of water, the following are pertinent points for thought:

(1) The density and frequency of algal blooms increase as the availability of nitrogen and/or phosphorus increase.

(2) In some lakes where this relationship has been studied it has been found that from .01 to .015 mg/l of soluble phosphorus, if present at the beginning of the growing season, is enough to grow blooms of algae of such character that many people find them objectionable.

Dr. Clair Sawyer is the man who first announced these numbers that I have relayed to you. I understand that he may be present in the audience today. I am not sure that he is.

This amount of phosphorus is equal to about 0.4 oz. mixed in an acre of water 1 foot deep. And, similarly,

(3) He also said 0.3 mg/l of inorganic nitrogen is all that is needed for such blooms of algae.

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This concentration is equal to 1 pound mixed in an acre of water 1 foot deep.

The significant point of all of this is that exceedingly minute concentrations of these nutrients are sufficient to cause trouble. It is necessary, therefore, to view every source of input with due respect.

Nutrients in Potomac River Water Entering D. C. Area Are There and They Are High.

Observations by the FWPCA during 1966 show an average annual total phosphorus concentration of about 0.1 mg/l in the Potomac River at Great Falls. Average concentrations of inorganic nitrogen were in the neighborhood of 1.0 mg/l. Similar concentrations of these two nutrients have been found by others who have studied the problem,^{1/ 2/} thus verifying that these values are real.

^{1/} Shapiro, J. and R. Ribeiro. Algal Growth and Sewage Effluent in the Potomac Estuary. JWPCF 37:1034-1043. July 1965.

^{2/} Carpenter, J. H., D. W. Pritchard and R. C. Whaley. Observations of Eutrophication and Nutrient Cycles in Some Coastal Plain Estuaries. Unpublished. Presented at the International Symposium on Eutrophication, Madison, Wis., June 1967.

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And, Mr. Chairman, at this point I would like, if I may, to submit for the record two publications, which are the ones I am referring to. They make the point that these numbers that we have gotten from our own observations are real numbers which have been verified by others.

I will simply identify these papers as being, first, a manuscript in which the authors are Carpenter, Pritchard and Whaley of the Chesapeake Bay Institute. The title is "Observations of Eutrophication and Nutrient Cycles in Some Coastal Plain Estuaries." This is a paper that was presented in June 1967 at an International Conference on Eutrophication in Madison, Wisconsin.

It is my understanding that publication is impending, and, if this is acceptable, I will submit this for the record.

SECRETARY KLEIN: We would be glad to have them, and I think, for purposes of clarification, if you will just mark them "Bartsch 1" and "Bartsch 2," that will be fine.

DR. BARTSCH: I will be pleased to do that.

Number is, which is Submission Bartsch No. 2, is entitled "Algal Growth and Sewage Effluent in the Potomac Estuary." The authors are Shapiro and Ribeiro,

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and the date of this is July 1965, published in the Journal of the Water Pollution Control Federation.

These things to which I have referred also have a special significance. You may have noted that this phosphorus level is about 7 times the critical level I specified a moment ago. As for the nitrogen concentration, it is about 3 times as great as needed. This means that the Potomac River now brings to the D. C. area waters a fertility of so high a level that in many lakes it is sufficient to set the stage for algal bloom problems. One might wonder why the upstream river itself does not now have troublesome algal blooms. The answer is that freely flowing rivers are physically not a favorable habitat for these algae. As the waters become quiescent in the Metropolitan Area, they acquire a lake-like character and then are suitable for growing algae.

Nutrient Input Through Wastewater Discharges

We are told that some 10 tons of phosphorus -- let me confess to not having a part in the collection of these data, and so I have to rely upon the good offices of my own colleagues in supplying me with the information which I now refer to.

In this light, we are told that some 10 tons

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of phosphorus and perhaps up to 27 tons of nitrogen reach the Upper Potomac Estuary waters daily in wastewater discharges from the surrounding area. The Washington, D. C. Metropolitan Area is a major source of such input. These nutrient inputs, superimposed on the fertility of Potomac River water entering the D. C. area, raise the phosphorus and nitrogen levels substantially. In the vicinity of Fort Washington, the inorganic (soluble) phosphorus level was found to be never less than 0.180 mg/l and sometimes reached about 5 times as much. Inorganic nitrogen generally was increased to more than 1.5 mg/l. On an annual average, phosphorus was 22 times the specified critical level, and inorganic nitrogen was 6 times the corresponding figure.

There is also another way in which such loadings may be viewed. A recent review of worldwide literature on algal production in lakes, which incidentally confirms the critical numbers I just mentioned to you, was made by Mr. Richard Vollenweider. He is a man now in charge of the Canadian Government research of eutrophication of the Great Lakes. This review was made by him for the Organization for Economic Cooperation and Development. His findings revealed that when the input rate of phosphorus to lakes was as great as $0.2-0.5 \text{ gm/m}^2/\text{yr}$, it was

sufficient to support objectionable algal blooms. Estimated inputs of phosphorus to the Upper Potomac Estuary in wastewaters alone are about 100 times this great. Similar critical loadings of nitrogen are 5-10 gms/m²/yr. Wastewater inputs are about 13 times this great. Fortunately, these nutrients are removed continuously from the scene by slow, downstream water movement. Without this growth-preventive nutrient outflow, bloom conditions likely would be even more frequent and more objectionable than they now are.

Increased Algal Production Stimulated

There are three principal kinds of evidence that nutrient additions contained in wastewaters stimulate algal production in the Upper Potomac Estuary: (1) the layman's casual observations that the algae are there and conditions are bad -- I think I need say nothing more about that observation -- (2) actual sampling and measurement of the crop, and (3) laboratory assays.

In sampling and measuring the algal crop, using chlorophyll as the test parameter, substantial increases in algal density were noted from Bellevue to Hallowing Point downstream from major sources of wastewater nutrient input. This is exactly what one would expect from

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the known inputs and distribution of nutrients.

Laboratory assays reported by Shapiro and Ribeiro in 1965 1/, which, if I recall correctly, is my Submission Number 2, showed that the addition of secondary wastewater treatment plant effluent to Potomac River water greatly increased the growth of both green and blue-green algae. The increase in growth was in proportion to the quantity of effluent added. The assays also showed that as little as 5% of added effluent was effectively stimulatory and at 40%, growth still continued to increase.

This means that a mixture of Potomac River water with wastewater effluents added to them is a much improved medium for growing algae. It was also found that phosphorus rather than nitrogen is the more significant nutrient in the wastewater, especially in supporting growth of blue-green algae.

Nutrient Removal as a Remedial Approach

Of the four major classes of remedial approaches tentatively available to curb eutrophication, ecological control is always the first and most favored consideration. Ecological control means changing the environment so that it becomes less suitable for growth of algae. The most straightforward way to do this is to limit

nutrient availability. Three crucial points relate to this: (1) the Upper Potomac Estuary already produces excessive crops of undesirable algae, and the need to decrease nutrient availability is apparent, (2) nutrient inputs from wastewaters enhance this production in proportion to the quantities added, and (3) laboratory assays show that removal of phosphorus will decrease production commensurate with the degree of removal.

Then, finally, with reference to my original Point Number 6,

Nutrient Control Program Needed Upstream

Ultimate control of the eutrophication conditions in the Upper Potomac Estuary cannot be attained by remedial efforts expended in the Washington, D. C. Metropolitan Area alone. Nutrient inputs to the estuary by way of the inflowing Potomac River already exceed concentrations known to cause problems in many lakes. From Three Sisters downstream at least to Fort Washington and perhaps beyond, the Potomac waterway is more like a lake than a river. One therefore can expect that these waters will react accordingly and likely could still grow substantial algal crops even if D. D. area inputs were to be substantially curtailed. In the light of this, it is necessary

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that serious consideration be given to establishing a systematic program for nutrient removal from all controllable sources, not only in the Washington, D. C. Metropolitan Area, but also in the Upper Potomac watershed.

Concluding Remarks

In conclusion, I want to say this: Eutrophication in the Potomac River system is not a unique occurrence. It is an element of a more widespread and sinister affliction affecting many susceptible waters of the land -- its rivers and reservoirs, its lakes, and more recently noticed, the estuaries. The forces at work are a combination of many complicated natural processes, with human overtones that accelerate them, and cause the loss of precious water resources to occur more quickly than otherwise. Thus far we have considered only the input of nutrients from wastewater sources. This is largely because they are substantial and because the technology for control is now available. But there are many other nutrient sources of concern, as shown in Table 1, and I will mention them briefly.

To restore and preserve the appeal and attractiveness of the Upper Potomac Estuary, tertiary treatment of all wastewaters for removal of as much phosphorus

TABLE 1.
ESTIMATE OF NUTRIENT CONTRIBUTIONS
TO U.S. SURFACE WATERS FROM VARIOUS SOURCES

Source	Nitrogen	Phosphorus
	1,000,000 lbs./year	1,000,000 lbs./year
Domestic Waste	1,100-1,600	200-500
Industrial Waste	> 1,000	---
Rural Runoff:		
Agricultural Land	1,500-15,000	120-1,200
Nonagricultural Land	400-1,900	150-750
Farm Animal Waste	> 1,000	---
Urban Runoff	110-1,100	11-170
Rainfall	30-590	3-9

Taken from the AWWA Journal, March 1967 - page 362

as possible should be accomplished without delay as a first, most necessary step in an intensive campaign. In addition, all other sources of input, both in the Washington, D. C. Metropolitan Area and the watershed upstream, should be brought under similar control as soon as possible. In addition to wastewaters such sources include as appropriate: storm drainages, urban runoff, drainage of agricultural and nonagricultural land, and wastes from feedlots and barnyards. For some of these sources, including rainfall, preventive technology does not exist. It is important, therefore, that research and development focus hard on such needs obviously necessary to provide for that kind of technology, and this not only for the Potomac River, but for the entire Nation.

Thank you.

(The following documents were submitted
by Dr. Bartsch for inclusion in the record:)

A. F. Bartsch

Bartsch #1

Observations of Eutrophication and
Nutrient Cycles in Some Coastal
Plain Estuaries

J. H. Carpenter

D. W. Pritchard

R. C. Whaley

Chesapeake Bay Institute,
The Johns Hopkins University

Contribution Number 108, Chesapeake Bay Institute
and Department of Oceanography, The Johns Hopkins Uni-
versity. This work was supported by contracts with the
Bureau of Environmental Hygiene, Maryland State Depart-
ment of Health and U. S. Department of Health, Education,
and Welfare and the Federal Water Pollution Control
Administration.

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Distributions of nitrogen and phosphorus compounds in the northern half of Chesapeake Bay and in the Potomac River downstream from Washington, D. C., have been observed for the past several years during monthly cruises of the Chesapeake Bay Institute. Several smaller tributaries (South, Severn, Magothy, Back, Chester and Miles Rivers and Eastern Bay) were surveyed also during these cruises. Measurements at each station (Figure 1) have been temperature, salinity, dissolved oxygen, pH, alkalinity, chlorophyll, transparency, inorganic phosphate, total filtrate phosphate, total phosphate, nitrate, nitrite, ammonia, total nitrogen, productivity and counts of net phytoplankton and zooplankton. The purpose of these surveys has been the determination of the existing conditions and nutrient levels to provide a basis for consideration of permissible increases in nutrient discharges or desirable reductions in some areas. This paper is a review of the salient features of the observed distributions.

Upper Chesapeake Bay

The upper Chesapeake Bay is primarily

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the estuary of the Susquehanna River, which drains central Pennsylvania and a portion of New York State. The mean annual discharge from the Susquehanna of 43,000 cfs. represents approximately 86% of the freshwater flow into the Bay above the mouth of the Potomac River. Weekly samples of Susquehanna River water have been collected during 1965-1966 to monitor the input into the upper Bay. The watershed of the Susquehanna River has extensive agricultural areas and a total human population in excess of one million people, so that considerable quantities of phosphorus and nitrogen are added to the river from these sources. The effects of these inputs are considerably modified by the passage of the river water through reaches with broad, shallow cross-sections and through a series of reservoirs where biological removal occurs. As a result, the river water that reaches Chesapeake Bay has a total phosphorus content of approximately $1.5 \mu\text{g}/\text{L}$ during winter and spring and approximately $1.0 \mu\text{g}/\text{L}$ during summer and fall. Most (85%) of the nitrogen in this water is in the form of nitrate; spring concentrations are $80\text{-}105 \mu\text{g}/\text{L}$, while $40\text{-}60 \mu\text{g}/\text{L}$ prevail during the other seasons. A significant fraction of the suspended sediments carried

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by the Susquehanna is trapped in the reservoirs in the lower reaches of the river. Consequently, the river water is relatively transparent by the time it reaches the Bay, with suspended solid contents of 10-20 mg/l., except for brief periods during early stages of high discharge.

The city and metropolitan area of Baltimore, Maryland, located 35 miles south of the entrance of the Susquehanna River into the Bay, has a population of 1,400,000 people. The Back River treatment plant of Baltimore produces approximately 150 million gallons per day of treated effluent of which approximately 100 million gallons per day is used as industrial water by the Bethlehem Steel Corporation and discharged into Baltimore Harbor, while the remainder is discharged into Back River, a tributary estuary of the Chesapeake Bay located just north of Baltimore Harbor.

The effects of these treated sewage discharges are not observable in the Chesapeake Bay below Baltimore. During the prolonged drought of 1965, discharge of the Susquehanna River was 4,000 cfs during July, August and September. The admixture of this inflowing fresh water with sea water produces a density driven

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circulation in the Bay off Baltimore with a flow in the upper layer of approximately three times the fresh water discharge or 12,000 cfs. This would provide a dilution for the sewage discharge of 1 to 50, which corresponds to a possible increase of 6 $\mu\text{g}/\text{L}$ phosphorus and 36 $\mu\text{g}/\text{L}$ nitrogen in the mixture. Such increases are not observed in the Bay. Algal growth in Back River is profuse and chlorophyll concentrations exceeding 60 $\mu\text{g}/\text{L}$ were observed throughout the March through November 1965, period, with 400 $\mu\text{g}/\text{L}$ observed in October. Decreases in chlorophyll and total phosphate in the area at the mouth of Back River of 5 to 7 fold are greater than can be expected by local dilution and deposition of the algal cells in the sediment appears to be the most probable process. Eutrophication in Back River is intense, but the effects are limited to this local area.

For the two-thirds of the effluent that is used as industrial water, an added constituent in the form of waste ferrous sulfate appears to have further effects in reducing the phosphorus additions to the Bay. The hydrolysis and oxidation of the added ferrous iron (100 tons per day) should be more than adequate to

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precipitate the phosphate (4 tons per day) in the effluent. The observed distribution of total iron in Baltimore Harbor suggests that more than 90% of the iron is nitrogen regeneration. Throughout this period more than one half of the total phosphorus is present as dissolved organic phosphate, indicative of continual production of this fraction.

Nitrogen regeneration on the bottom is not a major process in the upper Chesapeake Bay during the late spring and summer periods. For example, during July 1965, stations in the area off Annapolis, Maryland, showed nitrate concentrations of 4-6 $\mu\text{g atm/L}$ without significant variation with depth and ammonia concentrations of 3-5 $\mu\text{g atm/L}$ in the upper layer and 10-12 $\mu\text{g atm/L}$ in the lower layer. River flow was 4,000 cfs and had been uniform for the previous month. The observed salinities in the region showed a 3‰ difference between the upper layer and the lower layer. The longitudinal salinity gradient was 0.1‰ per mile. For this region the salinity distribution indicated a flow of 16,000 cfs in the upper layer, which is a drift of 0.02 knots or 0.5 miles per day. This amounts to an increase in salinity of 0.05‰ per day in the moving

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water of the upper layer, primarily as a result of mixing (exchange) with the lower layer. Since the difference in salinity between the upper layer and lower layer is 3‰, the time change in salinity corresponds to a vertical exchange rate 1.7% per day. With the 7 $\mu\text{g atm/L NH}_3$ difference between the layers, an addition of only 0.12 $\mu\text{g atm/L NH}_3$ per day to the upper layer is indicated.

The radiocarbon productivity measurements show that roughly 0.2 mg/L per day of organic carbon is being produced in the upper layer during the summer. This value is uncertain by perhaps a factor of 2, either high or low. However, this rate of carbon fixation corresponds to an uptake of 4 $\mu\text{g atm/L}$ nitrogen and 0.5 $\mu\text{g atm/L}$ phosphorus per day. Since, at this time, the concentration of inorganic nitrogen (nitrate, nitrite and ammonia) is roughly 8 $\mu\text{g atm/L}$ and the concentration of inorganic phosphate 0.1 $\mu\text{g atm/L}$ and dissolved organic phosphate 0.8 $\mu\text{g atm/L}$, the observed carbon fixation would result in utilization of all the available nitrogen and phosphorus in two days, or, taking into consideration the uncertainties, somewhere between 1 and 4 days. Since the chlorophyll, nitrogen and phosphorus concentra-

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tions do not change with time this rapidly and regeneration on the bottom or in the lower layer is not adequate, as shown above, rapid regeneration of phosphorus and nitrogen in the upper layer coupled with removal of chlorophyll is indicated. Grazing by zooplankton seems the most likely manner in which these two processes could occur. The standing crops of zooplankton appear more than adequate to consume the production.

While nutrient cycling between the upper layer and the lower layer and bottom does not seem to be important, deposition of nitrogen may be an important part of the nitrogen balance. As noted above, some 45 $\mu\text{g atm/L}$ nitrate nitrogen disappears from the water column during the late spring and summer. Estimates of sediment accumulation rates range around 1 mm per year. With 50% water content and 5% carbon, this amounts to 25 gm carbon per m^2 or 2 g atm per m^2 . The corresponding nitrogen deposition would be 500 mg atm per m^2 . The observed nitrate decrease amounts to 450 mg atm per m^2 , for the mean water depth of ten meters. Uncertainty in the sedimentation rate will not permit a precise calculation of nitrogen deposition, but the estimates are not discordant and the loss of nitrate appears to be

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adequately accounted for by deposition.

Potomac River

The Potomac River is tidal to just above Washington, D. C.; however, the salt water intrusion extends only to 20-30 miles below Washington. The fresh water region below Washington will be called the tidal river to distinguish it from the remainder of the estuary where the presence of salt water causes vertical density stratification and the characteristic estuarine two-layer circulation pattern. The sewerage systems of the Washington metropolitan area result in the discharge of 6 tons of phosphorus and 10 tons of nitrogen per day directly to the Potomac in the form of treated effluent. A series of cruises from March 1965, through April 1966, was conducted to observe the distributions of these materials in the tidal river and estuary.

The mean fresh water flow of the Potomac is 11,000 cfs. As shown in Figure 4, the study period was one of extreme summer drought with periods of 1,000 cfs discharge and brief periods of 80,000 to 90,000 cfs

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discharge. The Potomac watershed has extensive agriculture, but a smaller human population than the Susquehanna watershed. There are no significant reservoirs or broad reaches, so that upstream phosphorus and nitrogen removal is less than that observed in the Susquehanna discharge. Nitrate levels of 100 to 150 $\mu\text{g}/\text{m}^3$ and phosphorus levels of 5 $\mu\text{g}/\text{m}^3$ are present in the river just above Washington during periods of high discharge. During periods of lower flow, nitrate was found to be 50-70 $\mu\text{g}/\text{m}^3$ and phosphate 3-4 $\mu\text{g}/\text{m}^3$.

The additions of phosphorus and nitrogen below Washington produce very large concentrations locally. For example, at 3,000 cfs discharge, the phosphorus increase would be 30 $\mu\text{g}/\text{m}^3$ and the nitrogen increase would be 180 $\mu\text{g}/\text{m}^3$.

Such increases are not observed very far downstream. The total nitrogen distribution shows a seasonal pattern, with higher concentrations during January, February, and March (Figure 6). Nitrate increases are the principal constituent contributing to this pattern, with high nitrate concentrations occurring downstream in the estuary during March. Nearly complete removal of nitrate in the estuary occurs by June and

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nitrate levels are very low throughout the summer and fall (Figure 7).

The total phosphate distributions (Figure 8) show increases in the late fall and winter in the tidal river, movement downstream into the estuary during the high flow and, then, relatively moderate and constant concentrations throughout the summer and fall. Inorganic phosphate concentrations (Figure 9) are high in the tidal river and represent an appreciable fraction of the total in the tidal river. However, in the estuarine portion of the Potomac, inorganic phosphate concentrations greater than 0.5 $\mu\text{g}/\text{m}^3$ occur only after high river flow and the relative concentrations of total and inorganic phosphate are similar to those found in upper Chesapeake Bay.

The large decreases in total phosphate and inorganic phosphate concentrations downstream from Washington are suggestive of loss of phosphate from the water to the sediment. However, quantitative interpretation is complicated by the variable rate of river flow, which by itself would produce a longitudinal gradient downstream from the Washington discharge. The travel time from Washington to the mouth is so long that water

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that passed Washington at quite different rates is present in different portions of the estuary. Since the concentration of added phosphorus and nitrogen depends on the river flow rate past the discharge point, this time variation in flow rate produces a spatial variation in concentration downstream.

The high concentrations of chlorophyll (Figure 5) in the tidal river below Washington are produced primarily by *Microcystis aeruginosa*, which floats to form highly visual discolorations and collects on the shore line in unattractive mats. Lack of effective grazing on this alga may contribute to the large standing crop and ultimate deposition in the sediments of the algal colonies.

The estuarine portion of the Potomac River during 1965 did not have phosphorus and nitrogen concentrations greatly different from those observed in upper Chesapeake Bay. Correspondingly, the chlorophyll concentrations were not much higher in the estuarine Potomac than in upper Chesapeake Bay. However, the zooplankton populations in the Potomac were frequently 3 to 5-fold greater than those found in the upper Chesapeake Bay. The zooplankton are not adequately

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sampled in the small (100 ml) volumes used for chemical analyses. The phosphorus and nitrogen content of the zooplankton may represent an appreciable fraction of the total water column content. For example, *Acartia* ranged from 5 to 85 individuals per liter with 30 being a frequent value. This would amount to approximately 1 $\mu\text{g atm/L}$ of phosphorus in the region of the estuary where the "total" phosphorus was 1 to 1.5 $\mu\text{g atm/L}$. An adequate inventory will require analyses on zooplankton collected from large volumes and an extensive sampling program to estimate the zooplankton populations with the required precision.

An indication that eutrophication may be more pronounced in the estuarine Potomac than indicated by phytoplankton counts and chlorophyll concentrations is the dissolved oxygen decrease during summer in the lower layer. During 1965, oxygen depletion to levels less than 1 ml/L occurred in areas of the Potomac and comparable (salinity and vertical stratification) areas in upper Chesapeake Bay did not show depletion to less than 1 ml/L. Review of the dissolved oxygen data taken by the Chesapeake Bay Institute during the period 1950-

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1960 shows that the dissolved oxygen concentrations decreased more rapidly in the late spring and low (near zero) concentrations persisted for longer time periods in the estuarine Potomac than in upper Chesapeake Bay. These very low oxygen values are confined to the water layers below the halocline, with near saturation and supersaturation values occurring at the surface in both the Potomac estuary and the upper Chesapeake Bay.

Summary

The quantities of phosphorus and nitrogen discharged from the metropolitan areas of Baltimore, Maryland, and Washington, D. C., are large enough to produce great increases in the normal content of the upper Chesapeake Bay and Potomac estuaries. These discharges produce large algal populations locally, but apparent loss of phosphorus and nitrogen to the sediments restricts the pronounced effects to the local areas of the discharges.

This loss of phosphorus under conditions of enrichment is in contrast to the rapid cycling and near zero loss observed in the major portions of these

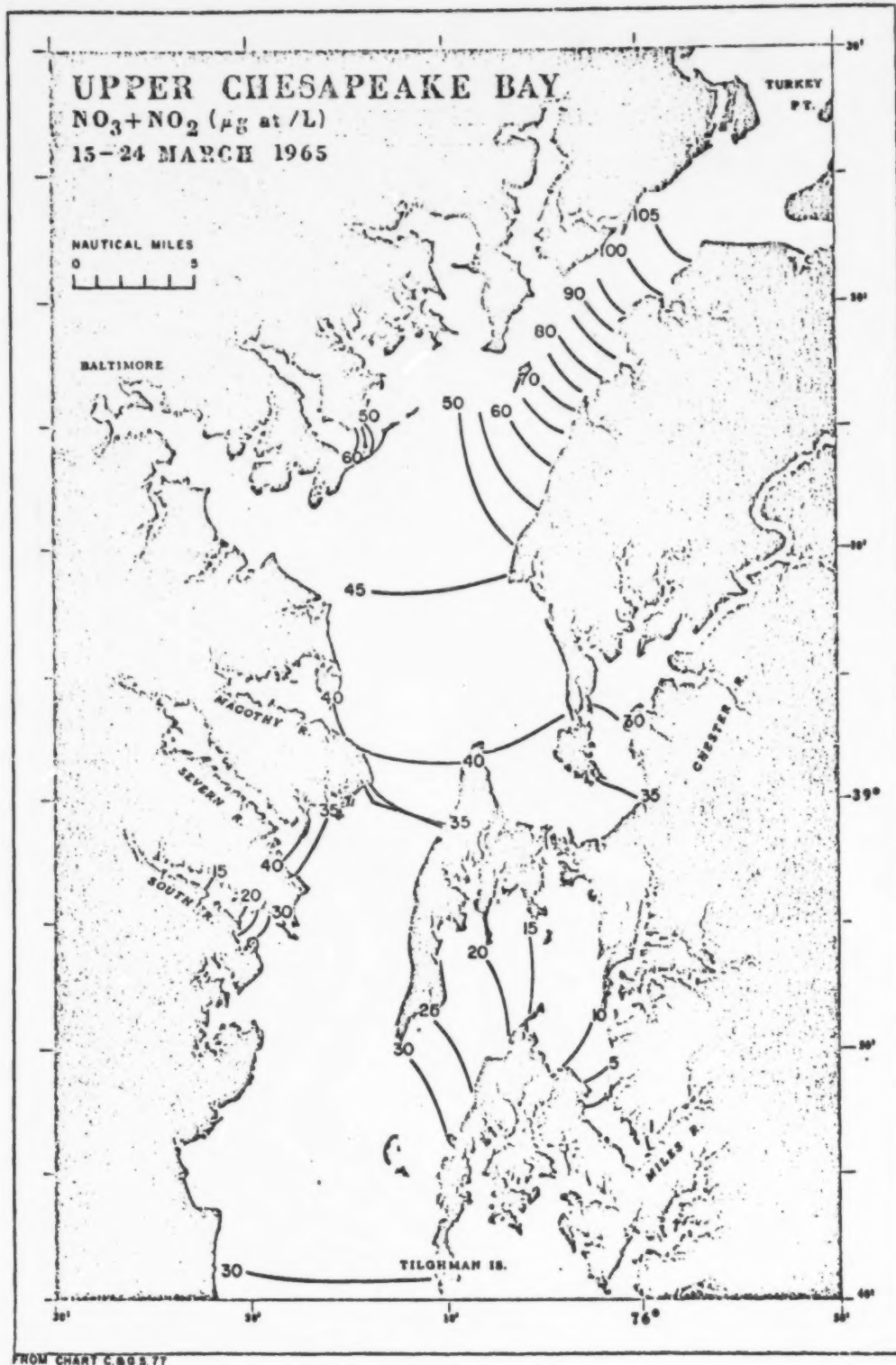
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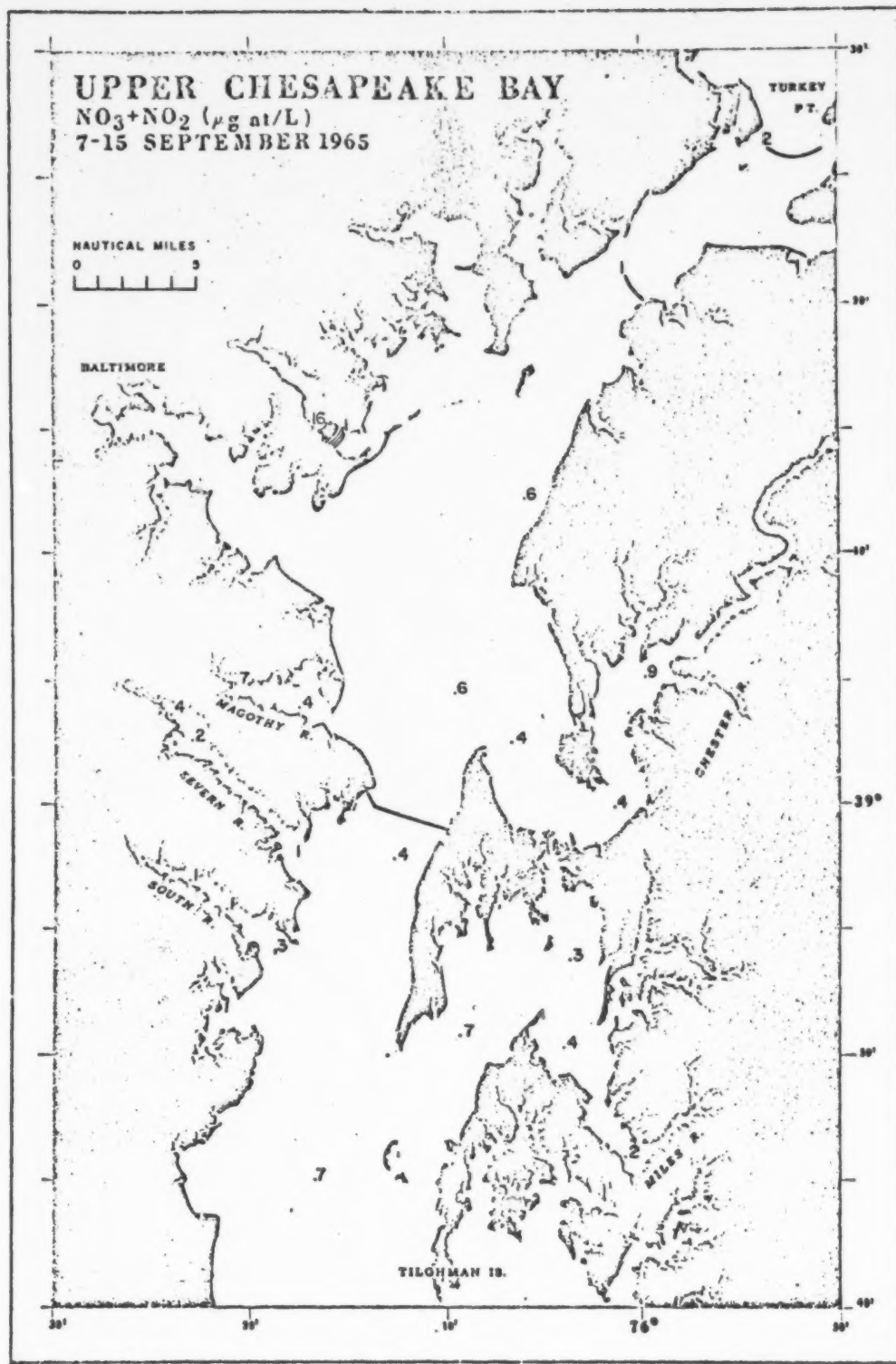
two estuaries with lower phosphorus concentrations. The lack of effective grazing by zooplankton in the enriched area appears to be responsible for the different phosphorus sequence.

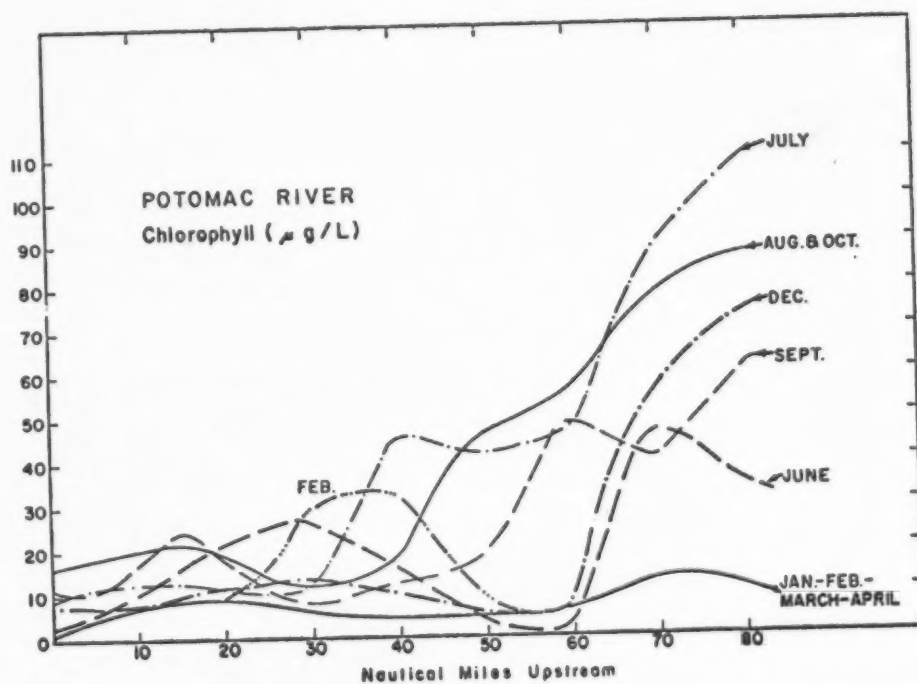
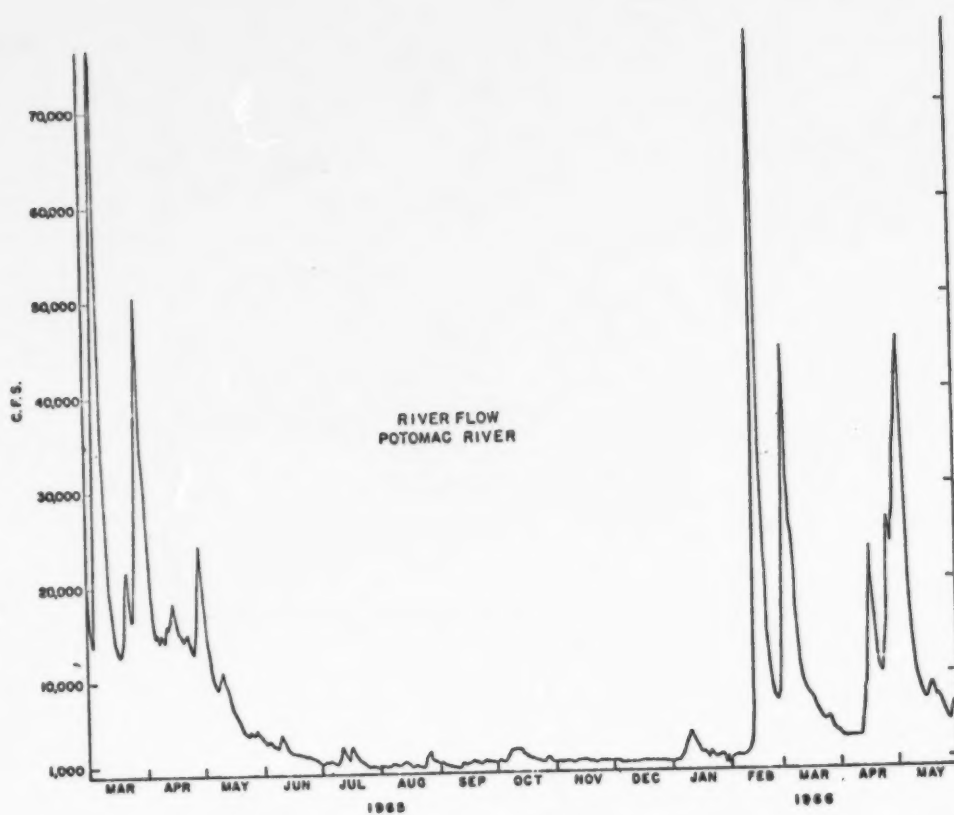
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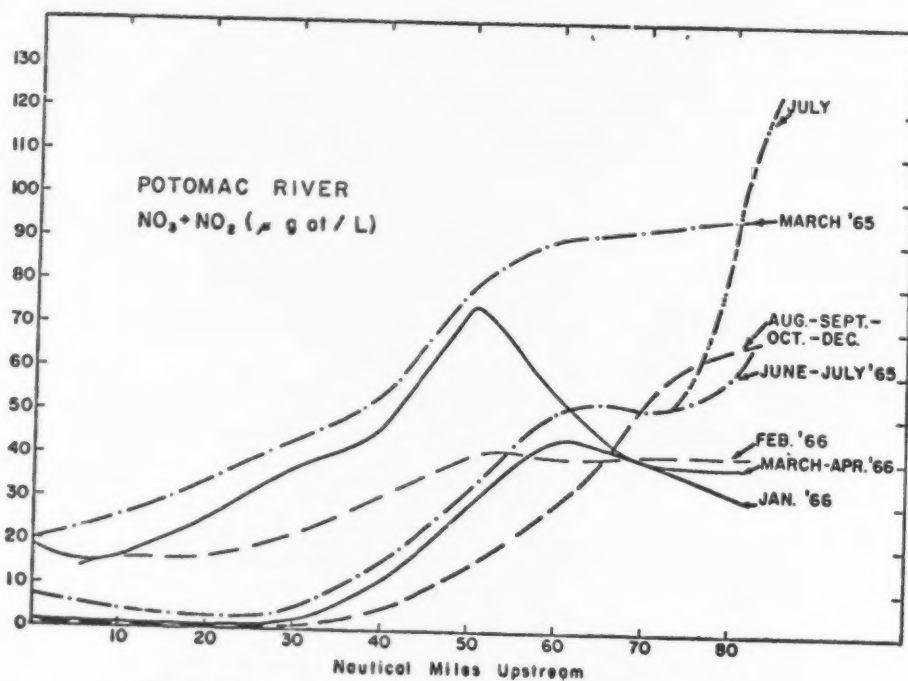
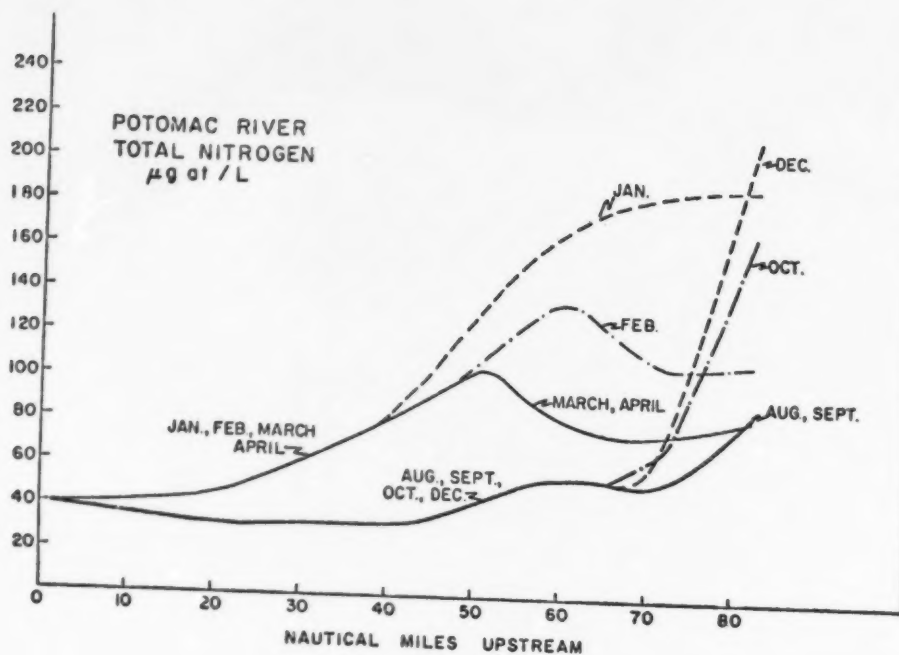
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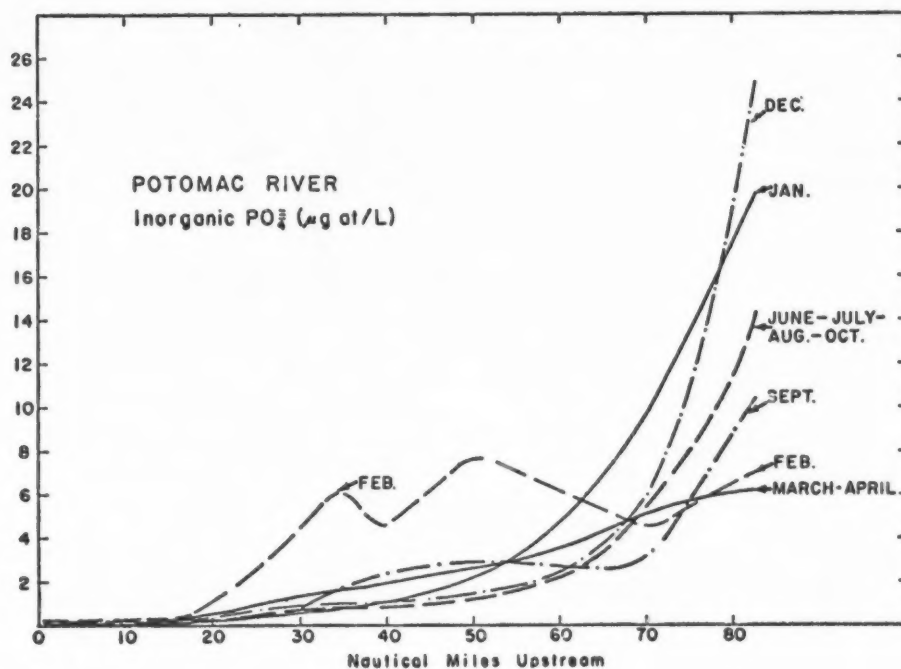
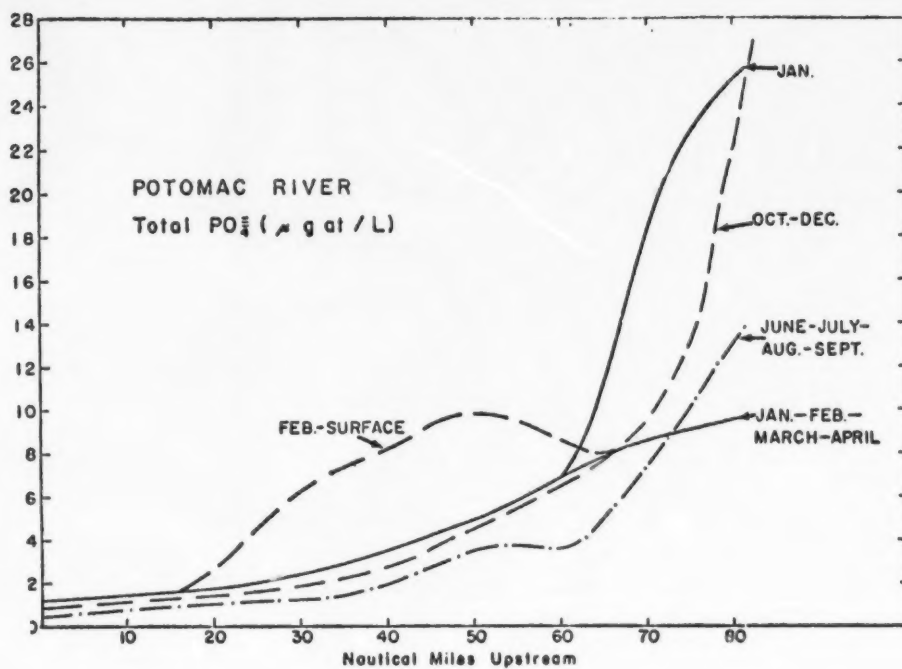


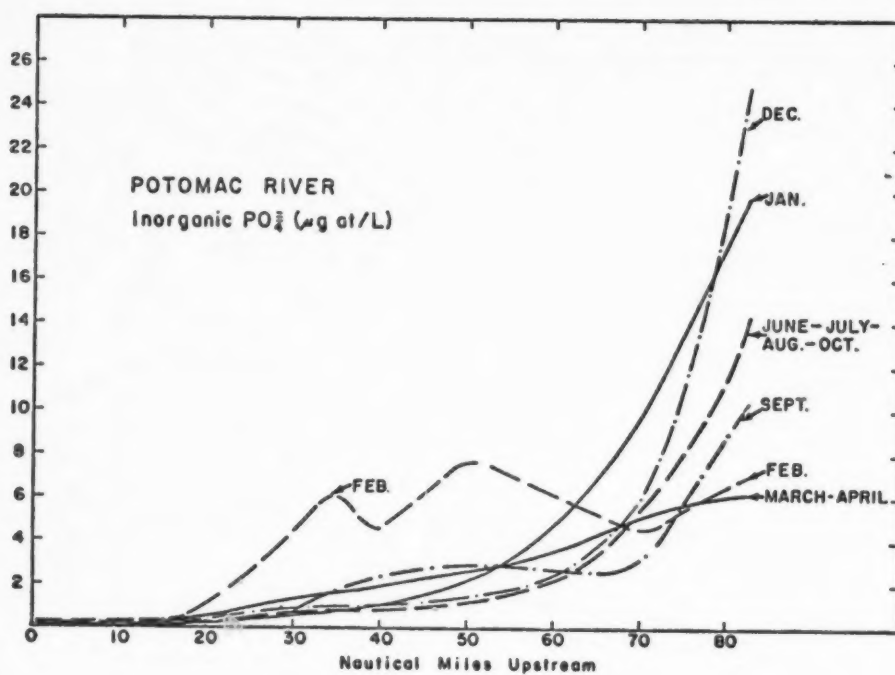
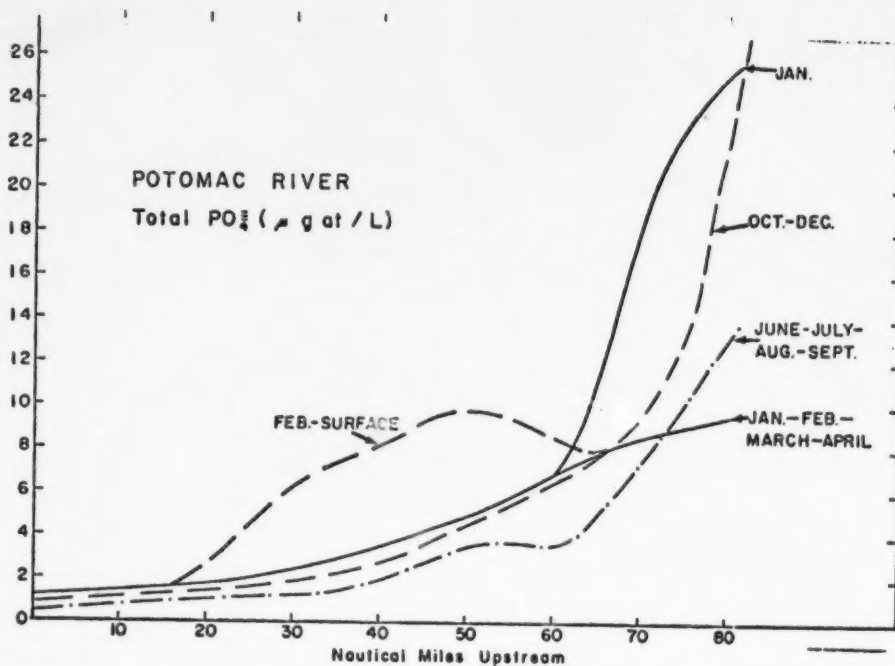












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ALGAL GROWTH AND SEWAGE EFFLUENT
IN THE POTOMAC ESTUARY

Joseph Shapiro and Roberto Ribeiro

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ALGAL GROWTH AND SEWAGE EFFLUENT
IN THE POTOMAC ESTUARY

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After entering the District of Columbia the Potomac River broadens and slows to become a tidal estuary. Since salt intrusion does not reach this far north it is a freshwater estuary and since in summer the combined flows of the Potomac and its tributary

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Anacostia require about 40 days to move 15 miles (24.2 km) downstream from Three Sisters Islands to Fort Washington, we may consider the Potomac estuary as akin to a freshwater lake. As such, it is subject to some of the phenomena which occur in lakes but not in rivers, including the abundant growth of free-floating algae. This occurs to such an extent that at time of lowest flow in summer huge blooms of algae appear which cloud the water and may even form floating mats (1) (2).

A study made in August 1950 (3) of the predominant algae showed, among others, the greens, *Pediastrum*, *Scenedesmus*, and *Ankistrodesmus*; the diatoms, *Stephanodiscus*, *Melosira*, and *Synedra*; and the blue-greens, *Anabena*, *Nostoc*, and *Oscillatoria*. While the presence of these algae probably is not dangerous to those who use the estuary for boating or swimming, their large numbers do result in esthetic degradation. This is true particularly of the blue-greens which tend to float and, therefore, are more susceptible to wind concentration and decomposition.

Because of the offensive nature of these algal blooms, their cause has generated much speculation. That is, while it is clear that the growth of the algae

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is made possible by an adequate supply of nutrients, particularly phosphorus and nitrogen compounds, the source of the responsible nutrients is in doubt. Are they initially present in the river, or are they added by the municipal water pollution control plant located near the southern boundary of the District of Columbia?

The reason that it is even possible to ask this question lies in the frequently high phosphorus levels of the Potomac River which range in the area above the District of Columbia from about 0.007 to 0.150 mg/l P as PO_4 (4).

These values may seem low to the uninitiated but they represent substantial amounts of phosphorus in terms of algal requirements. For instance, Sawyer (5) concluded from his observations on Wisconsin lakes that the critical level of phosphorus capable of supporting undesirable growths was 0.01 mg/l of PO_4P . Benoit and Curry (6) suggested the same figure in working on Lake Zoar, Connecticut, and numerous investigations by limnologists have shown algal blooms occurring at phosphorus levels well below this.

Thus, the ambient phosphate levels apparently are sufficiently high to support good algal

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crops. Then, do the blooms develop because the river slows down and essentially becomes a lake, or do they result from the increased nutrient load provided by the wastewater effluent? Figures obtained during August 1959 (7) show that the average phosphorus concentrations in the Potomac increase from 0.23 mg/l just above the tidal reach in the metropolitan area to 1.09 mg/l in the tidal area several miles below the water pollution control plant outfall. These figures were obtained after mild acid hydrolysis and represent the MIC (maximum inorganic concentration) of Engelbrecht and Morgan (8). However, since these authors showed that all this essentially would degrade to orthophosphate within several weeks, and since the mean residence period of water in the District of Columbia metropolitan area is about 40 days, it probably is safe to assume that most of this phosphorus becomes available to the algae.

With high levels of PO_4P normally present in the river, and with substantial quantities of PO_4P being added from the wastewater treatment plant, the only definitive approach to the problem seems to be an experimental one.

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EXPERIMENTS

The question to be answered was not whether Potomac River water alone would support algal growth, or whether wastewater treatment plant effluent would stimulate it, but whether the phosphorus level of the river water was sufficiently high that addition of sewage phosphorus would result in no substantial increase of algae. Therefore, the experiments were done using various mixtures of Potomac water and wastewater treatment plant effluent, with river water alone serving as control. This procedure also eliminated the danger described by Rodhe (9) in culture experiments using PO_4 , namely, the fact that PO_4 requirements of algae which are grown in medium made with distilled water may be many times the requirements of the same algae grown in medium made with natural (lake) water.

Two cultures of algae were used. One had developed originally in some effluent left standing in a window of the laboratory of the D. C. Water Pollution Control Plant. The vast majority of the cells were green algae of the genus *Scenedesmus*. A few filaments of the blue-green *Plectonema* were present, probably

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P. gloeophilum. This culture is, therefore, referred to as the green algae. The other culture developed in a sample of Potomac River water collected in December 1963 from the Wilson Bridge just below the treatment plant, and also was stored by a window. It consisted almost entirely of filaments of a blue-green, tentatively identified as *Nostoc paludosum*. Some cells of *Scenedesmus* also were present. This culture is referred to later as blue-green algae.

All cultures were grown, after inoculation, at 22°C in 250 ml Erlenmeyer flasks containing 100 ml of medium. Light was provided by fluorescent lamps yielding, at the distance of the cultures, about 350 ft-c (3,767 lumen/ sq m). Growth was measured in terms of dry weight (using tared, type HA, Millipore filters and making blank corrections), and chlorophyll, the latter by the method of Yetsch (10).

EFFECT OF EFFLUENT ADDITION

ON GROWTH

The first experiments were designed to compare the growth of cultures raised in river water

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alone with those raised in river water plus various amounts of effluent. This river water was collected at Chain Bridge just within the northwest boundary of D. C., kept in the cold room, and used throughout all experiments. The sample of effluent was collected from the channel leaving the secondary settling basins of the high-rate activated sludge plant and similarly stored and used. Repetition of the experiments with later samples of effluent showed no difference in results.

The dilutions of effluent in river water ranged from 5 to 40 percent and were chosen in accord with dilutions expected in actual practice; that is, the minimum summer flow of the Potomac measured above D. C. is about 800 cfs (1,360 cu m/min) or about 518 mgd (1.96 mil cu m/day), while the treatment plant effluent has a volume of about 200 mgd (757,000 cu m/day. A large proportion of the 200 mgd (757,000 cu m/day) effluent was originally a part of the 518 mgd (1.96 mil cu m/day) and, thus, by the time the river flows past the plant outfall about 40 percent of its flow may be effluent. The picture actually is more complex because the river does not really "flow" but sloshes back and forth with the tides. However, wastewater other than that from the D. C. plant

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finds its way to the river. Therefore, the figure of 40 percent represents an approximation to the worst possible condition.

The dilutions used and the resultant concentrations of $\text{PO}_4\text{-P}$ are shown in Table I. The effluent had an initial concentration of $\text{PO}_4\text{-P}$ of 5.2 mg/l. The results are shown in Figure 1 in terms of dry weight. In the case of the blue-green algae, the chlorophyll curves always mirrored the dry-weight curves. However, in the case of the green algae, the chlorophyll generally declined after the third day even though the dry weight continued to rise. Either the increase in dry weight was caused by the bacterial growth, or the drop in chlorophyll was caused by bleaching. Later experiments suggest the latter.

The results show clearly that addition of effluent to river water stimulates the growth of both groups of algae even at five-percent dilution. They also indicate that algal growths would increase if even greater concentrations than 40-percent effluent were used. The main question thus seems to have been answered, i.e., the river water alone is capable of supporting algae, but addition of plant effluent

TABLE I.—Phosphorus Concentrations in Mixtures of Potomac River Water and D. C. Water Pollution Control Plant Effluent

Effluent in River Water (%)	PO ₄ -P Concentration (mg/l)
0	0.037
5	0.295
10	0.553
20	1.07
40	2.10

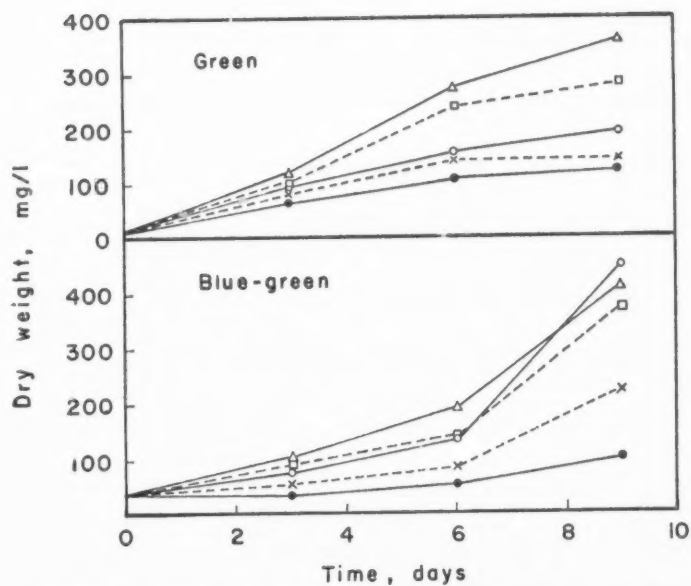


FIGURE 1.—Growth of green and blue-green algae cultured in Potomac River water (●) and in river water with the addition of various percentages (v/v) of sewage effluent. (x, 5 percent; ○, 10 percent; □, 20 percent; △, 40 percent.)

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increases their growth in proportion to the addition. This growth increase takes place within a short period of time, well within the residence time of the Potomac River in the Washington metropolitan area.

EFFECT OF PHOSPHORUS ALONE

The question now arises as to whether the growth-stimulating ability of the effluent is due solely to its phosphorus content. To determine this, the algae were cultured in river water to which was added orthophosphate in amounts which would have been added had wastewater effluent been mixed with the water in dilutions of 0, 5, 10, 20, and 40 percent, respectively. The results, plotted in Figure 2, show that the growth of the green algae is enhanced only slightly, if at all, over that in river water alone, and that of the blue-green algae was increased, but only after a lag of several days. However, by the end of nine days the blue-greens had achieved populations as high as when cultured with the effluent instead of only with its equivalent of $\text{PO}_4\text{-P}$.

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NATURE OF GROWTH STIMULATING
SUBSTANCES

Thus, while the wastewater effluent stimulates growth of both groups of algae over that which can occur in the river water, it is a different component of the effluent which is the effective agent for each group, i.e., the phosphate stimulates the growth of the blue-greens and some other factor causes the greens to grow. Wastewater effluent contains what can be described only as a galaxy of compounds, ranging from trace elements and vitamins to amino acids and various inorganic nitrogen compounds. Therefore, an attempt was made to determine whether the factor stimulating the green algae was an accessory growth substance or a major nutrient. The experiment was done by growing the algae in river water to which were added five-percent effluent plus the phosphate which would be present at effluent concentrations of 5, 10, 20, and 40 percent, respectively. Thus, if the algae at these concentrations grew as well as in the corresponding effluent dilutions, the stimulating factor would be a substance required

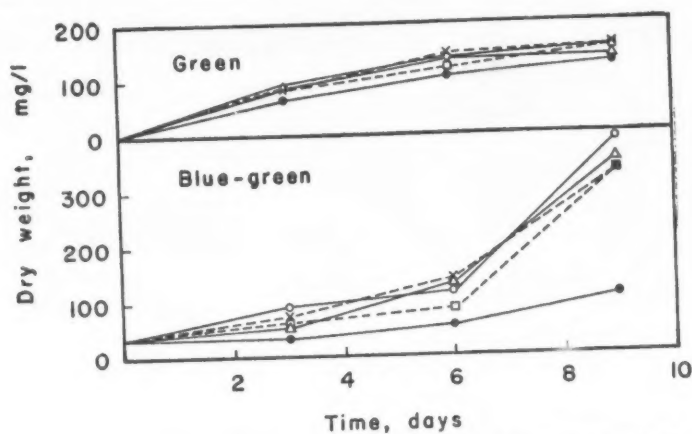


FIGURE 2.—Growth of green and blue-green algae cultured in Potomac River water (●) and in river water with the addition of orthophosphate in an amount equivalent to that which would have been added had sewage effluent been added in the following (v/v) percentages; (×, 5 percent; ○, 10 percent; □, 20 percent; △, 40 percent).

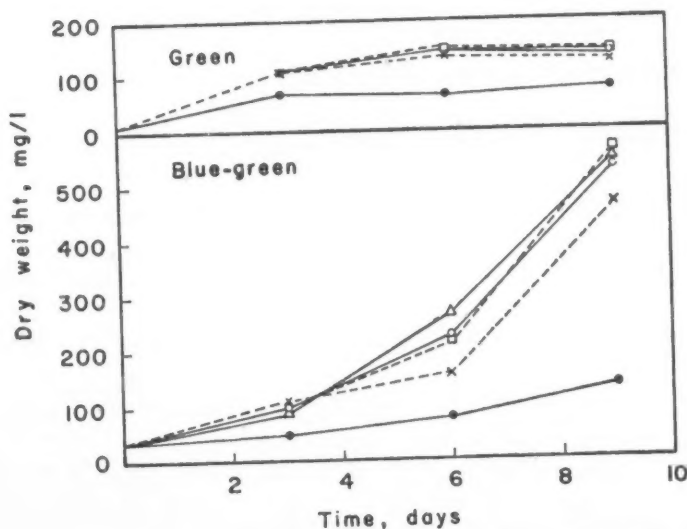


FIGURE 3.—Growth of green and blue-green algae cultured in Potomac River water (●) and in river water plus 5 percent (v/v) of sewage effluent (×). Added to the latter was an amount of orthophosphate sufficient to raise the concentration to that which would have been present if: ○, 10 percent; □, 20 percent; and △, 40 percent (v/v) of sewage effluent had been used.

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only in small concentrations since it most likely would be present in excess in the effluent. On the other hand, if the growth of all cultures was essentially equal, the stimulating factor probably would be a major nutrient, the concentration of which was limiting. The data, plotted in Figure 3, show that the latter is probably true, i.e., the factor allowing the green algae to grow abundantly is very likely not a trace element or a vitamin but some substance which is required in quantity. As expected under the same circumstances, the blue-green algae grew well, perhaps even better than with phosphate alone.

The problem now was to determine which major nutrient was limiting to the green algae. Cultures were set up using Potomac River water alone and river water to which were added various combinations of the following substances: $\text{Ca}(\text{NO}_3)_2$, MgSO_4 , MnSO_4 , Na_2SiO_3 , ferric citrate and trace elements. The last were used to verify the hypothesis that trace substances were not the limiting factors. Curiously, none of the cultures showed any increase in growth over the river water by the third day. This suggested that perhaps through shortage of some other nutrient the one which was

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limiting could not manifest itself. Therefore, on the third day, each of the cultures was divided into two flasks, phosphate was added to one, and the other was allowed to grow as usual. The results were striking. Within one day each flask containing CaNO_3 or some combination of CaNO_3 and the other substances, and to which PO_4 had been added, was bright green. Figure 4 shows a typical set of results. The data for chlorophyll are plotted also to show the dramatic change resulting from addition of PO_4 .

The experiments thus far indicate the following:

1. Both groups of algae are stimulated by the addition of effluent to the river water.
2. The blue-greens are stimulated equally by phosphate alone.
3. The stimulation of the greens is not due to phosphate alone but apparently results from a nitrogen source in the effluent. (The possibility exists from the experiments that it is the calcium which did the stimulating but calcium also was present in the trace elements which had no stimulatory effect and, also, this is unlikely from experiments on nitrogen

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removal as will be shown later.)

4. Addition of the nitrogen source alone will not allow further growth of the greens, i.e., when the nitrogen is abundant, phosphate is limiting; when the phosphate is abundant, nitrogen is limiting. Thus, for stimulating growths of the green algae it is necessary to add both as in adding effluent to river water.

Since both groups of algae ultimately require the same elements for growth, including nitrogen, it would seem as though the river water had sufficient nitrogen compounds to allow for abundant growth of blue-greens, i.e., that the 0.33 mg/l of $\text{NH}_3\text{-N}$ (no nitrate is present) is enough for this group. This is most unlikely in view of the generally high nutrient requirements of blue-greens (11) and it is more reasonable that these algae were using their demonstrated ability (12) (13) to fix and use atmospheric nitrogen. Indeed, the lag observed in the cultures to which only phosphate was added (compare Figures 1 and 2) probably was caused by the time necessary for the nitrogen-fixing mechanism of the algae to become fully operative.

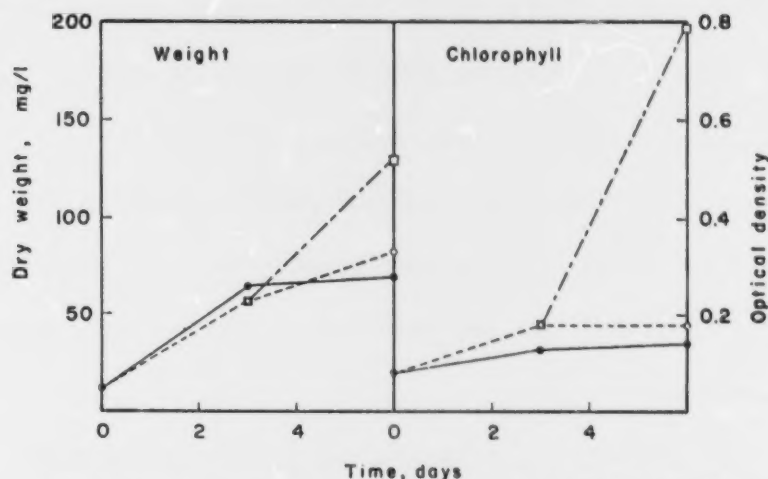


FIGURE 4.—Growth of green algae cultured in Potomac River water (●), in river water plus CaNO_3 (○), and in river water plus CaNO_3 and orthophosphate (□). The nitrate-containing culture was divided into two flasks on the third day and the phosphate was added to one of these.

TABLE II.—Phosphorus and Nitrogen Concentrations in Original and Treated Effluents

Effluent	$\text{PO}_4\text{-P}$		$\text{NH}_4\text{-N}$	
	mg/l	%	mg/l	%
Original	5.20	100	38.4	100
Treated with $\text{Fe}_2(\text{SO}_4)_3$	0.071	1.36	38.4	100
Treated with $\text{Fe}_2(\text{SO}_4)_3$ and aerated; PO_4 restored	4.8	92.1	14.8	38.5

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EFFECTS OF REMOVAL OF NITROGEN
AND PHOSPHORUS

In considering the application of these results to the problem of the blooms in the Potomac, the practical question arises as to whether removal of the nutrients from the wastewater treatment plant effluent would help control the blooms. This, of course, is suggested by the results, which indicate that removal of either nitrogen or phosphorus would limit the growth of the greens while only phosphorus removal would be effective in blue-green control. However, it seemed worth-while to verify these hypotheses and so experiments were done in which the algae were cultured in effluent treated to remove nitrogen or phosphorus.

Procedure

Phosphorus was removed from a sample of effluent by adding 200 mg/l of ferric sulfate. A portion of this effluent was filtered and set aside. The rest was filtered and aerated for several hours after its

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pH had been raised to 9.5 with KOH. This removed a considerable amount of the inorganic nitrogen which was present entirely as ammonia. Then, sufficient KH_2PO_4 was added to this effluent to restore its PO_4 content. Thus, three effluents were available having the composition shown in Table II.

The algae were cultured using these effluents to make dilutions with the river water in the usual way. The experiments with the unmodified effluent were not repeated, these results already being shown in Figure 1. The results with the green algae are shown in Figure 5. Reducing the $\text{PO}_4\text{-P}$ content of the effluent reduces the growth at 40-percent dilution in 9 days from about 370 to about 80 mg/l. Similarly, lowering the nitrogen level by 62 percent reduced the growth at 40-percent dilution in 9 days from 370 to 200 mg/l or 55 percent. These results agree with the earlier findings.

The results for the blue-greens shown in Figure 6 agree with the hypothesis that the blue-greens respond only to the phosphorus of the effluent. Reduction of the $\text{PO}_4\text{-P}$ by 99 percent curtailed growth over that in the river water almost completely, while reduction of the nitrogen by 62 percent had no negative effect, and, in

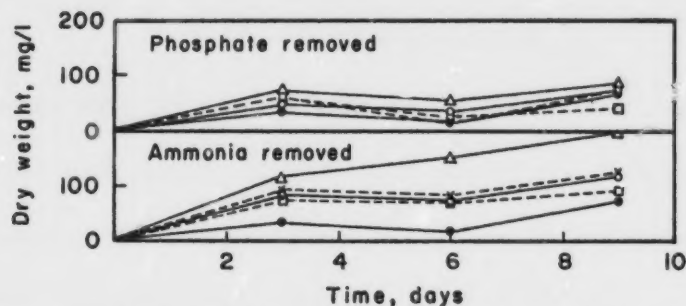


FIGURE 5.—Growth of green algae cultured in Potomac River water (●) and in river water containing various percentages (v/v) of sewage effluent from which either the phosphate or ammonia had been removed. (x, 5 percent; ○, 10 percent; □, 20 percent; △, 40 percent.)

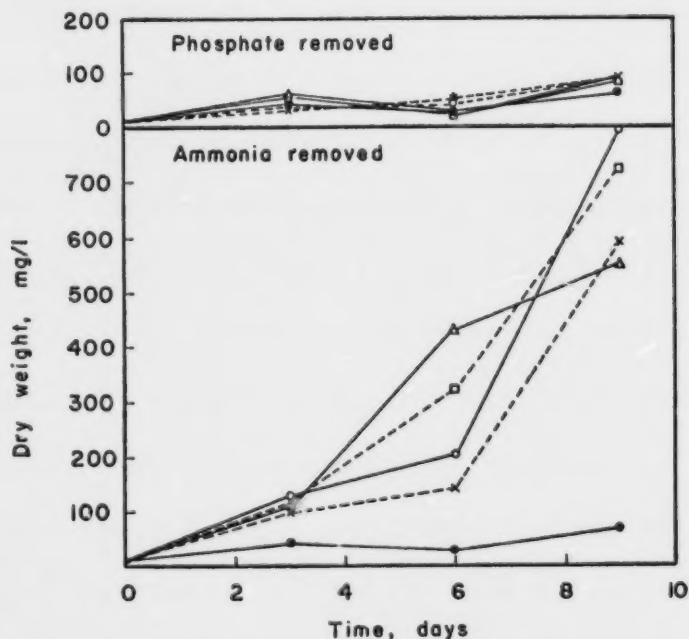


FIGURE 6.—Growth of blue-green algae cultured in Potomac River water (●) and in river water containing various percentages (v/v) of sewage effluent from which either the phosphate or ammonia had been removed. (x, 5 percent; ○, 10 percent; □, 20 percent; △, 40 percent.)

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fact, seems to have stimulated the growth of the algae. This latter effect suggests that the high ammonia content of the wastewater actually may inhibit the growth.

In any event, the conclusions are clear. Removal of $\text{PO}_4\text{-P}$ will control the growth of both algae while the removal of NH_3 will control only the greens.

POSSIBLE IMPORTANCE OF SILT

One factor not considered here is the silt carried by the Potomac River (14). The most obvious way in which this could affect the application of the results would be through its effect in lowering light penetration into the river to the extent that the nutrient level became of secondary importance. However, blooms do occur in the Potomac River and, so, light penetration must be sufficient. In any event, the experiments were performed in shallow layers of medium, about two- to three-cm thick, and could, thus, represent at least surface conditions. It is clear that if the silt problem is ever solved light penetration will increase and may result in greater algal growths.

The other way in which silt could be

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involved would be through adsorption of phosphates or ammonia onto the silt particles. In the experiments described previously, the river water had been settled before use and so no silt was present. Therefore, if adsorption normally occurs, resulting in making the N and P unavailable to the algae, the algal growth could be expected to be less than demonstrated. However, this same settled water when analyzed had a $\text{PO}_4\text{-P}$ concentration of 0.037 mg/l and a $\text{NH}_3\text{-N}$ concentration of 0.33 mg/l. It is, therefore, unlikely if these quantities of substances were not adsorbed completely by the silt, that the many times greater quantities would be. Again, however, if the silt problem ever is solved, there would be no absorption and, this, if adsorption is at present of significance, could lead to greater algal growths. Thus, solution of the silt problem through building of dams must be tied to an appropriate program of nutrient control.

CONCLUSIONS

These findings are of significance not only for the Potomac River but for other enriched surface

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waters as well. There is a tendency in considering nutrient removal from wastewater effluents to concentrate on nitrogen removal (15) (16) rather than on phosphorus removal. This possibly is because denitrification is a relatively inexpensive operation compared to chemical precipitation. However, as shown by the data presented here, nitrogen removal may not be sufficient. Elimination of the nitrogen will control the green algae, but the blue-greens are unaffected due to their ability to fix nitrogen and it is usually these algae that are most obnoxious. Furthermore, if a sufficient population of blue-greens develops, it ultimately may, through nitrogen fixation, decay, and regeneration of nutrients, provide enough nitrogen so that blooms of greens also occur. Elimination of nitrogen from effluents, by helping to eliminate green algae, may reduce competition and, thus, actually stimulate the blue-greens. Finally, elimination of only nitrogen from effluents may result in less awareness of the possible dangers of putting effluents into surface waters, i.e., it may lead to a false sense of security shattered only too late by a thick, smelly scum of algae.

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SUMMARY

1. Addition of secondary wastewater treatment plant effluent to Potomac River water greatly increases the growth of both green and blue-green algae in proportion to the quantity of effluent added.

2. As little as 5 percent of effluent is effective and 40 percent is not supraoptimal.

3. The sole component responsible for stimulating the blue-green algae is $\text{PO}_4\text{-P}$, these organisms being able to provide their own nitrogen supply through fixation of molecular nitrogen.

4. The green algae require both $\text{PO}_4\text{-P}$ and $\text{NH}_3\text{-N}$ of the wastewater effluent for growth stimulation.

5. Removal of the ammonia from the effluent will control the green algae only but phosphate removal will limit the blue-greens as well.

6. Partial removal of phosphorus from the effluent will control both algal groups to a degree commensurate with the degree of removal.

7. The normal phosphorus concentration

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of the Potomac River is such that an increase in this concentration will stimulate further algal growth.

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SECRETARY KLEIN: Thank you. I think that was very well put.

Ordinarily, though we would ask you questions, because of the fact that we know what the next presentation is going to be, we will ask you to step down and go to the next, and ask the two of you questions at once.

Mr. Jensen.

MR. JENSEN: Mr. Chairman, our next speaker is Dr. David Stephan, Assistant Commissioner for Research and Development of the Federal Water Control Administration. He will speak on the current technology for the removal of nutrients from wastes.

Dr. Stephan.

STATEMENT OF
DR. DAVID G. STEPHAN
ACTING ASSISTANT COMMISSIONER
RESEARCH AND DEVELOPMENT
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
U. S. DEPARTMENT OF THE INTERIOR
WASHINGTON, D. C.

DR. STEPHAN: Mr. Chairman, Commissioner,

Dr. D. G. Stephan

Conferees, Ladies and Gentlemen:

The previous speakers have concerned themselves primarily with a discussion of the problem with suggestions as to how we can get about solving the problem, and I hope to be the first one to present you with some positive information which I hope that you can take under consideration with regard to some methodology, the performance of these methods that were described, and perhaps of key importance to all of you, the costs associated with them.

I would like to address my remarks in general to the concept of advanced waste treatment, and that means going beyond the capability which we had in dealing with municipal and industrial wastes perhaps at the turn of this decade. Specifically, I shall refer to work that has been going on in this area and I shall describe for you some of the pilot plant experimental and developmental work that has been conducted here in the Washington area.

I appreciate this opportunity to discuss recent advances in the waste treatment field and the role of the FWPCA in developing and applying new technology for the treatment of wastewaters.

The objective of FWPCA waste treatment

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research and development program is to develop and demonstrate the technology necessary to achieve, at lowest cost, any level of waste treatment which may be required to meet pollution control needs. The methods being developed frankly range across the spectrum of physical, chemical and biological techniques. They range from the "ordinary," such as filtration or gravity settling, through the "novel," such as biological denitrification, and on to the "exotic," if you will, for example, reverse osmosis or ultrafiltration. Techniques are under study to improve the performance of conventional secondary treatment, as well as to develop and apply entirely new "tertiary treatment" methods.

I would like to point out there are actually two corollary objectives to be attained through improved waste-treatment technology. The obvious one to all of us is the alleviation of the Nation's increasing water pollution problems through removal of pollutants from waste effluents; the other less obvious one in many areas is the renovation of wastewaters for deliberate reuse as industrial, agricultural, recreational, or, in some cases, even municipal supplies. In point of fact, these two objectives cannot really be separated for, if you think about

it, as our ability to cleanse wastewaters increases, the resulting product water approaches nearer and nearer to or may even exceed the quality of a water supply. This concept, which is perhaps startling to the average citizen, will nonetheless play a larger and larger role in water resource management especially in water-short areas in this country.

The Federal Government program to develop and demonstrate advanced waste-treatment and wastewater renovation methods was initiated in 1961. During the eight years of this program some \$25,000,000 have been invested in research and development on new waste treatment technology. Within the last two or three years, I believe the fruits of this program have become apparent with the emergence of several advanced waste treatment (AWT) systems into the demonstration plant phase.

We believe that FWPCA investment in time and money has paid off handsomely in that first generation process technology capable of achieving greatly improved pollution control of municipal wastes has already been brought to the stage of full-scale demonstration and is now available for use under many conditions. To illustrate the importance of these developments, may I have Slide 1?

Let me refer to this table for a comparison between the removal capabilities of conventional waste treatment and what is now being achieved in a full-scale advanced waste treatment demonstration plant now in operation. Conventional treatment can nominally remove 90% of the suspended solids and BOD; advanced waste treatment can exceed 99%. Where perhaps 95% of coliform bacteria are eliminated in a conventional process, AWT knocks out over 99.99% of such bacteria. With regard to nutrients, a conventional system may remove about one-half of the nitrogen in the raw waste; advanced treatment can attain up to 97% or 98%. Phosphorus removal averages around 30% in a typical primary-secondary treatment plant; a tertiary phosphorus removal installation can up this removal to well over 90%.

While these improvements in percent removals are impressive enough in and of themselves, the impact on pollutional loads discharged to a stream is even more dramatic. Remember that an increase in removal efficiency from 90 to 95 percent reduces the amount of pollution actually entering the stream by a factor of 2. An increase from 90 to 99 percent reduces the pollutional load by a factor of 10! A concept that not all of us recognize, I think.

TABLE I

Comparison of Removal Capabilities of
Conventional and Advanced Waste Treatment

<u>Pollutant</u>	<u>Conventional primary- Secondary treatment plant</u>	<u>Advanced waste treatment demonstration plant</u>
Biodegradable organics (BOD)	90%	99+
Total Organics (COD)	80%	96%
Suspended solids	90%	99+
Phosphorus	30%	99+
Nitrogen	50%	50-98%
Coliform bacteria	95%	99.99%

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The FWPCA research and development program on advanced waste treatment technology is centered at our laboratory in Cincinnati, Ohio. However, a task of this magnitude requires the talents of the best scientific and engineering minds in this field in the entire country, regardless of whether they are in government, in the universities, or in industry. Because of this, much of the work has been carried out through contract and grant projects from one end of this country to the other. Appendix A, which I will provide, gives a summary picture of the status of process development and the locations at which this work has been or is being conducted. This effort has, in turn, stimulated private industry to enter this field to a most heartening degree. Chemical manufacturers, equipment fabricators, consultants, even the aerospace industry have responded to this challenge. As a result, the technology available today is not just one-of-a-kind and custom-built for experimental purposes. Believe me, a host of private firms stand ready to take orders for planning and design studies, for construction, and for equipment, chemicals, etc. At a two-day Phosphate Removal Workshop which we held last June in Chicago, for example, over a dozen companies presented their own treatment

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techniques for removing phosphorus from wastewater.

One of the most productive mechanisms we have utilized in our own process development work has involved the establishment of cooperative projects with various municipalities. At the present time, for example, we have a large variety of AWT pilot plants in actual operation at joint Federal-local field sites at Lebanon, Ohio, Pomona, California, and right here in Washington, D. C. Such joint projects give us the practical experience and first-hand knowledge required to bring research out of its ivory tower and into the hard realities of design, operational, and maintenance problems and to measure our successes (and our failures) in terms of that universal index, dollars.

In this light, I would like to discuss the joint effort we have been conducting with the District of Columbia's Department of Sanitary Engineering since 1965. This project gives direct insight into the waste treatment problems of the Potomac Basin and can provide a directly-applicable design basis for a full-scale advanced waste treatment facility at the District's Blue Plains Water Pollution Control Plant.

Fundamentally, the pilot plant at Blue

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Plains consists of three steps -- each designed to accomplish specific objectives in upgrading the quality of the Blue Plains secondary effluent. The first step, treatment with chemicals, is used to remove nutrients. The second step, filtration through beds of sand and coal, removes any remaining suspended solids or particulate matter. The third step is treatment with activated carbon. This substance, made by "activating" fine particles of coal or other organic materials at high temperatures, is the type of material used in gas masks or even in some filter cigarettes to adsorb or collect organic molecules. Used in a waste treatment system, this active carbon removes the dissolved biodegradable organics (BOD) and other organic molecules which have passed untouched through the entire previous treatment train. As a result of this 3-step treatment, the 50,000-gallons-per-day pilot plant can produce sparkling clear product water which, when disinfected with a small dose of chlorine, approaches very closely to drinking water in quality.

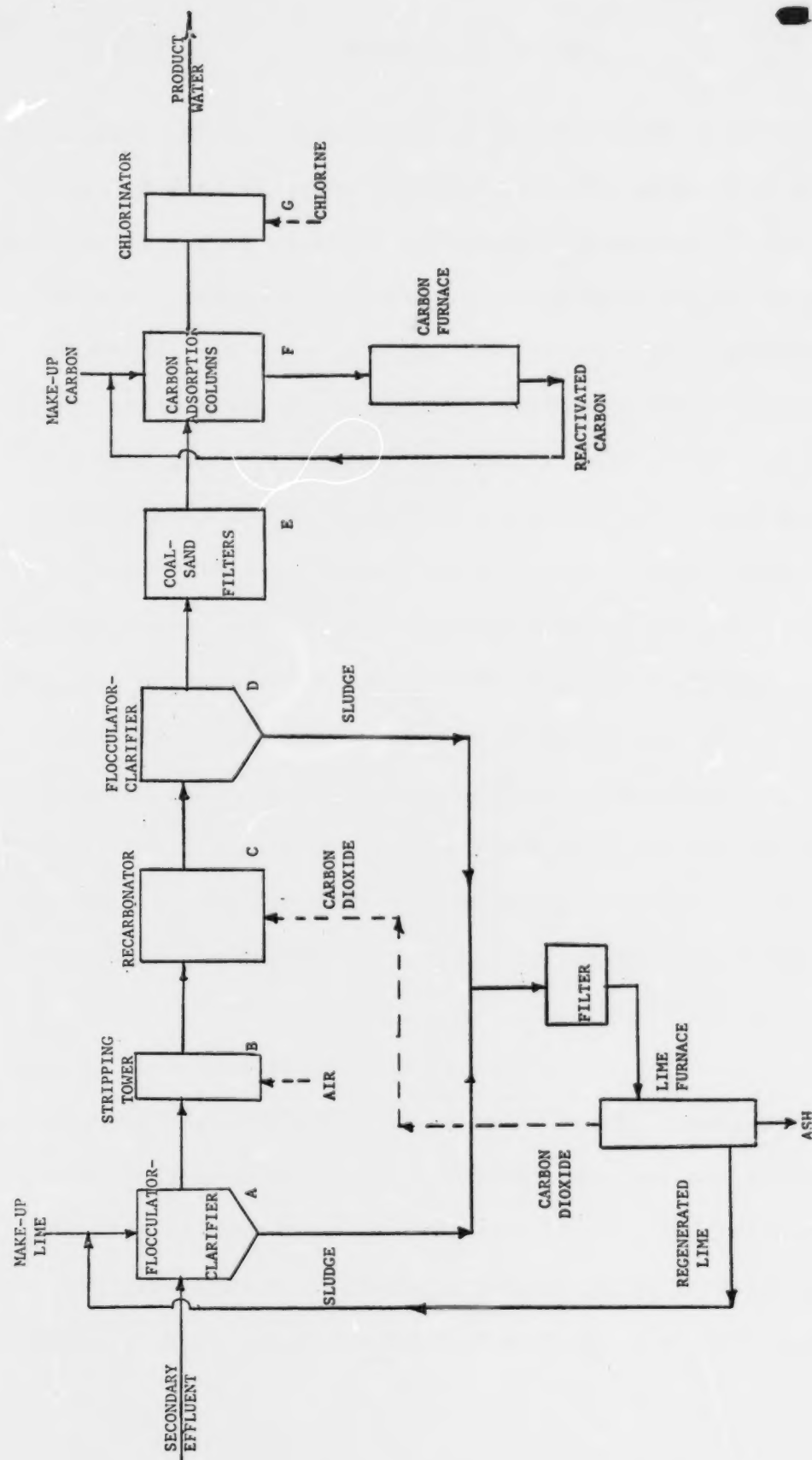
Incidentally, there is perhaps a vivid demonstration of this in the hall outside of the conference room where you will see a jug of what I am told is secondary effluent from the plant. I didn't collect it so I am

not sure where it came from. And next to it is an aquarium which contains the effluent from our pilot plant at Blue Plains. In the aquarium we are growing tropical fish -- not goldfish, but tropical fish, one of which I paid four dollars for.

The complete tertiary treatment is illustrated in the next slide and the next chart. I will go through this very briefly, but try to give you a quick summary of what the treatment system is like that is now being applied in Washington.

Ordinary lime (calcium hydroxide) is added in the first tank, A, on the left. This lime makes the water highly alkaline and also reacts with the phosphorus present to form a solid material or precipitate. The solid formed, calciumhydroxyapatite, settles to the bottom of the tank and is removed as a sludge. Along with the phosphorus much of the suspended organic particulate matter present in normal secondary effluent is also carried down with the sludge and removed. The product from this tank is highly alkaline and in this condition, when air is blown through the water in tank B, nitrogen in the form of ammonia is removed. The alkaline condition also imposes a severe biological shock on bacteria, thus also

FIGURE 1
COMPLETE TERTIARY TREATMENT SYSTEM



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serving to provide partial disinfection of the water. In the next tank, the recarbonator, which is tank C, carbon dioxide is bubbled through the water to soften it as well as to remove alkalinity. Another precipitate, calcium carbonate, is formed; this material also settles to the bottom of the second settling tank, D, where it is removed as a sludge. This sludge, incidentally, along with that from tank A is filtered and then it is incinerated in a special furnace in the "lime recycle system." In this way, fresh lime is regenerated for reuse in the system and carbon dioxide is formed which serves to supply the recarbonator. As much as 60-70 percent of the lime required can be recovered and reused in this process. Thus, lime purchases need only be about 1/3 of the amount actually used. Some dry ash is discharged from this process but this is sterile and non-pollutional in nature and may be disposed of as landfill.

Returning to the main flow stream through the tertiary plant, which is the blue line you see running across the top, the discharge from tank D is then passed through beds of coal and sand, E, very much as utilized in existing water treatment plants. In this step the very fine, non-settling particles are filtered from the

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water producing a clear effluent ready for the activated carbon adsorption columns, F. The active carbon removes essentially all of the dissolved organic residues in the water and, frankly, produces a water so clean that a BOD measurement cannot accurately be made upon it. The activated carbon, of course, becomes gradually saturated with these organics and periodically the carbon is removed from the contact tanks and "reactivated" in a furnace. This reactivation burns the collected organic materials to carbon dioxide and water and the rejuvenated carbon is reinstalled back in the process and reused. The product water from the carbon columns, F, is of quite high quality and, as a final step, is disinfected with a conventional chlorinator, G.

Next, let me refer you to this slide, Table II, to illustrate the pollutant removals nominally achieved through each step of a primary-secondary-tertiary waste treatment system I have just described to you. Note that conventional primary-secondary treatment as now commonly practiced will remove about 90% of both the BOD and the suspended solids, about 80% of the total organics present, about 30% of the phosphorus, 50% of the nitrogen, and perhaps 95% of the coliform bacteria. The chemical

TABLE II

Removal of pollutants through primary-secondary-tertiary treatment system

Pollutant	Primary Sedimentation	Activated Sludge	Treatment step:			Activated Carbon Adsorption	Chlori- nation	Total Removal
			Chemical Precipitation- Stripping	Filtration				
Biodegradable organics (BOD)	35%	90%	94%	95%	99%	-	99%	
Total organics (COD)	30%	80%	88%	90%	98%	-	98%	
Suspended solids	35%	90%	95%	99%	-	-	99%	
Phosphorus	10%	30%	95%	99%	-	-	99%	
Nitrogen	15%	50%	90%	-	-	-	90%	
Coliform bacteria	60%	95%	98%	99%	-	99.99%	99.99%	

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treatment step of a tertiary treatment plant will increase removal of each of these pollutants quite significantly. The filtration step also contributes to additional removals of each pollutant except nitrogen. The activated carbon adsorption effectively eliminates all the remaining BOD and almost all of the total organics; a relatively low dose of chlorine provides for disinfection to 99.99% or more.

I must point out, incidentally, that disinfection is readily accomplished with conventional chlorine even when the water being treated is chemically and physically clean, and the problem of disinfection relates not to the inefficiency of pouring in itself, but because of interferences which occur due to the presence of other pollutants in those effluents.

For your interest, primary effluent may be considered to provide partial pollution control but no direct reuse of the effluent is possible. Activated sludge effluent achieves "conventional" pollution control; the effluent may occasionally be reused for rough industrial purposes or for non-food crop irrigation in arid areas. This is rather common practice in the southwest of this country. The effluent from the chemical treatment step

contains only a little more than half of the BOD load from an activated sludge plant, only half the troublesome suspended solids and coliform bacteria, and is highly treated for the nutrient elements, phosphorus and nitrogen; such an effluent achieves much improved pollution control and, with disinfection, the effluent could be reused as a general irrigation supply, as a low quality industrial water for process or cooling purposes, and even for non-body contact recreation. With filtration, the water becomes suitable for a broad range of industrial purposes and with activated carbon adsorption treatment, we have achieved complete organic pollution control and the product water is really of high enough quality for any irrigation purpose, for essentially any industrial requirement and even for body contact recreation.

The next question to be raised, I am sure, is a natural: What will such treatment facilities cost to build and to operate?

May I have the next slide? Table III summarizes projected full-scale costs for a typical municipal waste treatment plant in terms of 1969 dollars. As seen, the addition of a chemical treatment step for nutrient removal will cost some \$14 million for a 100-mgd plant.

TABLE III

Projected costs for a 100 mgd primary-secondary-tertiary treatment system
(1969 dollars)

<u>Treatment Step</u>	<u>Capital Cost (million\$)</u>		<u>Operating & Maintenance Cost (cents/1000 gal.)</u>	
	<u>Each Process</u>	<u>Cumulative</u>	<u>Each Process</u>	<u>Cumulative</u>
Primary Sedimentation	10	10	2	2
Activated Sludge	23	33	4	6
Chemical Precipitation- Stripping	14	47	6	12
Filtration	3	50	2	14
Activated Carbon Adsorption	12	62	5	19
Chlorination	1	63	1	20

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I have keyed this table, incidentally, to a 100 million gallons per day flow rate. For any given instance, you can ratio these costs rather directly up and down for different flow rates.

Now, this \$14 million amounts to a 43% increased investment over that required for primary-secondary treatment facilities alone. Filtration for suspended solids removal would add another \$3 million or 7% to the prior costs. Activated carbon facilities will run another \$12 million and add 24% to the previous total while chlorination will require less than \$1 million and add less than 2% to the capital cost. Because economy of scale advantages are only slight above plant sizes of 100 mgd, a 300-mgd plant to handle Washington, D. C.'s 1978 wastewater flow rate would require roughly three times the above dollar amounts plus land and site preparation costs, plus other ancillary facilities that may be necessary, for example, to handle stormwater overflows.

Typical operation and maintenance costs for large plants are also presented in Table III. As seen, the added operating cost for achieving nutrient removal with tertiary chemical treatment is about 6 cents per 1000 gallons which equals the cost of operating a present-day

primary-secondary treatment plant alone. To add filtration raises the cost by an additional 2 cents per 1000 gallons while carbon adsorption will cost some 5 cents per 1000 gallons more. The cost of chlorination is minimal and will add less than 1 cent per 1000 gallons to the operating and maintenance costs of the system.

In one sense, certainly the costs projected are considerable. The capital investment for advanced waste treatment, and I am talking here about advanced waste treatment all the way to an extremely high quality effluent essentially free of BOD and nutrient pollution, amounts to almost twice that for conventional practice. Operating costs are over three times those for operating today's plants! On the other hand, I suggest an analysis from another perspective. The additional capital investment calculates out to some \$37 or \$38 per individual served. Assuming a useful life of 20 years for purposes of argument, this amounts to less than \$2 per year per person. With interest rates at, say 6-1/2%, the cost per year per person is only about 1 cent per day. I might also ask that you compare this \$38 per capita investment with that for our gas, phone, and electric utilities. These capital investments amount to \$125, \$310, and \$433, respectively.

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As for operating cost, let's take a look at it in the same way. The 14 cents per 1000 gallon figure associated with a complete AWT system beyond conventional treatment is less than 2 cents per person per day. To this, let us add the 1 cent per day figure given above for the capital amortization. This 3 cents per day compares with an average per capita expenditure of 13 cents per day for gas, almost 22 cents per day for phone service, 26 cents per day for electricity for the community, 80 cents per day for food, and even 12-15 cents per day per capita for cigarettes.

I cannot judge what is an acceptable cost to make the Potomac truly a model stream for the Nation. I do, however, submit to you that treatment technology now exists to effectively eliminate the sewerage municipal waste load to this stream and that the cost to do so is roughly only one-fourth of what we now spend for cigarettes!

(Appendix A follows.)

APPENDIX A

SUMMARY OF ADVANCED WASTE TREATMENT PROCESS DEVELOPMENT STATUS IN U. S.

<u>Treatment Process</u>	<u>Scale</u>	<u>Location</u>
Activated Sludge - Modified	100 mgd field evaluation being planned 750,000 gpd field evaluation being planned 3 mgd pilot plant being planned 300,000 gpd pilot plant in design stage Two 100,000 gpd pilot plants in design stage 75,000 gpd pilot plant in design stage 14,000 gpd pilot plant in design stage	Los Angeles, Calif. Dallas, Tex. Chino, Calif. Irvine, Calif. Washington, D. C. San Buenaventura, Calif. Nassau County, L.I., N.Y.
Adsorption-Granular Activated Carbon	7.5 mgd demonstration plant under construction 5.0 mgd demonstration plant in design stage 750,000 gpd field evaluation plant in design stage 500,000 gpd pilot plant near completion 300,000 gpd pilot plant in operation 150,000 gpd pilot plant in design stage 100,000 gpd pilot plant in design stage 75,000 gpd pilot plant in operation 50,000 gpd pilot plant in operation 15,000 gpd pilot plant in operation 14,000 gpd pilot plant studies underway	So. Lake Tahoe, Calif. Piscataway, Md. E. Chicago, Ind. Nassau County, L.I., N.Y. Pomona, Calif. Hemet, Calif. Santee, Calif. Lebanon, Ohio Washington, D. C. Ely, Minn. Nassau County, L.I., N.Y.
Adsorption-Fluidized Carbon Beds	7,000 gpd pilot plant in design stage	Trenton, N.J.
Adsorption-Powdered Activated Carbon	15,000 gpd pilot plant in operation 15,000 gpd pilot plant in design stage	Lebanon, Ohio Roanoke, Va.
Adsorption-on Inorganics	Rejected*	
Adsorption-on Coal	15 gpd bench-scale studies completed Laboratory studies completed	Cleveland, Ohio Pittsburgh, Pa.
Adsorption-on Polymers	Rejected*	

<u>Treatment Process</u>	<u>Scale</u>	<u>Location</u>
Ammonia Stripping	7.5 mgd demonstration plant under construction 200,000 gpd pilot plant in design stage 100,000 gpd pilot plant in design stage	So. Lake Tahoe, Calif. Prince Wm. County, Va. Washington, D. C.
Bio-denitrification-tank	2 mgd field evaluation plant in design stage 200,000 gpd pilot plant in design stage 100,000 gpd pilot plant in design stage 100 gpd bench-scale unit in operation	Santee, Calif. Prince Wm. County, Va. Washington, D. C. Cincinnati, Ohio
Bio-denitrification-column	300,000 gpd pilot plant in design stage 800 gpd bench-scale studies underway	Irvine, Calif. Pomona, Calif.
Bio-nitrification	300,000 gpd pilot plant in design stage 200,000 gpd pilot plant in design stage 100,000 gpd pilot plant in design stage 100 gpd bench-scale studies in operation	Irvine, Calif. Prince Wm. County, Va. Washington, D. C. Cincinnati, Ohio
Biological Phosphate Removal	23 mgd field evaluation completed 3 mgd pilot plant being planned 300,000 gpd pilot plant in design stage 100,000 gpd pilot plant in design stage 100,000 gpd pilot plant in design stage Laboratory scale studies underway	San Antonio, Tex. Chino, Calif. Irvine, Calif. Detroit, Mich. Washington, D. C. Ada, Okla.
Biomass Treatment	300,000 gpd pilot plant studies completed	Lancaster, Calif.
Combined Chem-biological Treatment	Bench-scale studies completed	Tucson, Ariz.
Coagulation-Inorganic	7.5 mgd demonstration plant under construction 5.0 mgd demonstration plant in design stage 2 mgd field evaluation plant in design stage 750,000 gpd field evaluation plant in design stage 500,000 gpd field evaluation plant in design stage 500,000 gpd pilot plant under construction 300,000 gpd pilot plant being planned 150,000 gpd pilot plant planned 150,000 gpd pilot plant in design stage	So. Lake Tahoe, Calif. Piscataway, Md. Santee, Calif. E. Chicago, Ind. Lancaster, Calif. Nassau County, L.I., N.Y. Irvine, Calif. Dallas, Tex. Hemet, Calif.

Treatment Process

Scale

Location

Coagulation-Inorganic (Cont'd.)

100,000 gpd pilot plant under construction
 100,000 gpd pilot plant in operation
 75,000 gpd pilot plant in operation
 70,000 gpd pilot plant studies completed
 15,000 gpd pilot plant in operation
 15,000 gpd pilot plant in operation
 14,000 gpd pilot plant in design stage
 7,000 gpd pilot plant in operation

Detroit, Mich.
 Washington, D.C.
 Lebanon, Ohio
 Lancaster, Calif.
 Stanford, Calif.
 Ely, Minn.
 Nassau County, L.I., N.Y.
 Pomona, Calif.

Coagulation-Organic Polyelectrolyte

200 mgd field evaluation study underway
 120 mgd field evaluation study underway
 10 mgd field evaluation study under design
 100,000 gpd pilot plant in design stage

Washington, D. C.
 Cleveland, Ohio
 So. St. Paul, Minn.
 Washington, D. C.

Disinfection

7.5 mgd demonstration plant under construction
 5.0 mgd demonstration plant in design stage
 2 mgd field evaluation plant in design stage
 500,000 gpd field evaluation plant in design stage
 3 mgd pilot plant being planned
 500,000 gpd pilot plant near completion
 500,000 gpd pilot plant in operation
 300,000 gpd pilot plant in design stage
 75,000 gpd pilot plant studies planned
 60,000 gpd pilot plant in design stage
 50,000 gpd pilot plant in design stage
 Two 50,000 gpd pilot plants in design stage

So. Lake Tahoe, Calif.
 Piscataway, Md.
 Santee, Calif.
 Lancaster, Calif.
 Chino, Calif.
 Nassau County, L.I., N.Y.
 Pomona, Calif.
 Irvine, Calif.
 Lebanon, Ohio
 Hemet, Calif.
 Washington, D. C.
 Santee, Calif.

Distillation

1,000 gpd pilot plant studies completed
 Laboratory studies completed

Waterford, Conn.
 Cincinnati, Ohio

Electrochemical Degradation

Rejected*

Electrodialysis

75,000 gpd pilot plant in operation
 50,000 gpd pilot plant planned
 7,000 gpd pilot plant studies completed
 7,000 gpd pilot plant in operation
 50 gpd bench-scale studies underway

Lebanon, Ohio
 Santee, Calif.
 Orange County, Calif.
 Pomona, Calif.
 Cambridge, Mass.

Treatment Process

Electrolysis

Emulsion Separation

Eutectic Freezing

Extraction of Contaminants

Extraction of Water

Filtration - Coal

Filtration - Diatomaceous Earth

Filtration - Rapid Sand and
Multi-Media

Scale

Laboratory studies completed

Rejected*

Rejected*

Rejected*

Rejected*

240,000 gpd pilot plant under construction

250,000 gpd pilot plant studies in progress

150,000 gpd pilot plant in design stage

75,000 gpd pilot plant studies completed

70,000 gpd pilot plant studies completed

15,000 gpd pilot plant in operation

4,000 gpd pilot plant studies completed

7.5 mgd demonstration plant under construction
5.0 mgd demonstration plant in design stage
2 mgd field evaluation plant in design stage
750,000 gpd field evaluation plant in design stage
500,000 gpd field evaluation plant in design stage
500,000 gpd field evaluation plant in design stage
300,000 gpd pilot plant in design stage
150,000 gpd pilot plant in design stage
150,000 gpd pilot plant in design stage
100,000 gpd pilot plant in design stage
75,000 gpd pilot plant in operation
35,000 gpd pilot plant in operation
30,000 gpd pilot plant study completed
15,000 gpd pilot plant study completed
14,000 gpd pilot plant in operation
5,000 gpd pilot plant studies ready to start
5,000 gpd pilot plant studies completed

Location

Philadelphia, Pa.

Cleveland, Ohio

Pomona, Calif.

Hemet, Calif.

Pomona, Calif.

Lebanon, Ohio

Stanford, Calif.

Lancaster, Calif.

So. Lake Tahoe, Calif.

Piscataway, Md.

Santee, Calif.

E. Chicago, Ind.

Lancaster, Calif.

Nassau County, L.I., N.Y.

Irvine, Calif.

Dallas, Tex.

Hemet, Calif.

Washington, D. C.

Lebanon, Ohio

Lancaster, Calif.

Lancaster, Calif.

Stanford, Calif.

Nassau County, L.I., N.Y.

Lebanon, Ohio

<u>Treatment Process</u>	<u>Scale</u>	<u>Location</u>
Flotation	1.0 mgd pilot plant under construction 300,000 gpd pilot plant in design stage 100,000 gpd pilot plant in design stage 50,000 gpd pilot plant studies completed	Prince Wm. County, Va. Irvine, Calif. Washington, D. C. Lancaster, Calif.
Foam Harvesting	Rejected*	
Foam Separation - Simple	500,000 gpd pilot plant studies completed 10 gpd bench-scale studies completed 10 gpd bench-scale studies completed	Pomona, Calif. Long Island City, N.Y. Linden, N.J.
Foam Separation - with Additives	15,000 gpd pilot plant in design stage 10 gpd bench-scale studies completed	San Jose, Calif. Long Island City, N.Y.
Freezing	Rejected*	
Hydration	Rejected*	
Ion Exchange	15,000 gpd pilot plant in operation 15,000 gpd pilot plant in operation 12,000 gpd pilot plant in design stage 3,000 gpd pilot plant in operation	Ely, Minn. Stanford, Calif. Santee, Calif. Pomona, Calif.
Ion Exchange - Removal of Organics	Bench-scale studies in progress	Berkeley, Calif.
Microscreening	75,000 gpd pilot plant studies completed	Lebanon, Ohio
Oxidation - by Catalytic Autoxidation	Laboratory tests ready to start	Paramus, N. J.
Oxidation - by H ₂ O ₂	Rejected*	
Oxidation - Light Catalyzed Chlorine Oxidation	Laboratory studies underway	Kansas City, Kan.
Oxidation - by O ₃	240 gpd bench-scale studies underway	Murray Hill, N. J.

<u>Treatment Process</u>	<u>Scale</u>	<u>Location</u>
Oxidation - by Corona Discharge	Rejected*	Washington Ct. House, Ohio
Oxidation - by Autoxidation	Rejected*	Xenia, Ohio
Phosphate Removal - through Mineral Addition	1 mgd field evaluation completed 1 mgd field evaluation completed 100,000 gpd pilot plant in design stage 200 gpd bench-scale studies in progress 100 gpd laboratory scale studies completed	Washington, D.C. Cincinnati, Ohio Cincinnati, Ohio
Reverse Osmosis	Five 10,000 gpd pilot plants in design stage 5,000 gpd pilot plant in operation 4,000 gpd pilot plant in operation 3,000 gpd pilot plant in design stage	Hemet, Calif. Pomona, Calif. Pomona, Calif. Lebanon, Ohio
Trickling Filter	75,000 gpd pilot plant in design stage	San Buenaventura, Calif.
<u>Disposal Processes</u>		
Adsorbate Incineration	Carbon regeneration for 7.5 mgd plant under construction Carbon regeneration for 5 mgd plant in design stage Carbon regeneration for 2.5 mgd plant in operation Carbon regeneration for 750,000 gpd plant in design stage Carbon regeneration for 500,000 gpd plant under construction Carbon regeneration for 300,000 gpd plant in operation	So. Lake Tahoe, Calif. Piscataway, Md. So. Lake Tahoe, Calif. E. Chicago, Ind. Nassau County, L.I., N.Y. Pomona, Calif.
By-product Recovery	Exploratory studies--desk top	

Treatment Process

Scale

Location

Disposal Processes (Cont'd.)

Coagulant Regeneration	Lime recovery for 7.5 mgd plant under construction Coagulant recovery for 5 mgd plant in design stage Pilot scale studies underway Pilot scale studies underway Bench-scale studies underway	So. Lake Tahoe, Calif. Piscataway, Md. Washington, D.C. So. Lake Tahoe, Calif. Cincinnati, Ohio
Foam Recycle	Exploratory studies - Laboratory tests completed	
Incineration	Pilot scale studies planned	Washington, D.C.
Injection	Exploratory studies--desk top	
Nuclear Cavities	Exploratory studies--desk top	
Excavated Cavities	Rejected*	
Ocean Dumping	Exploratory studies--desk top	
Pipelining	Field evaluation installation in design stage Pilot studies in design stage Bench-scale studies completed	Morgantown, W. Va. Chicago, Ill. Cleveland, Ohio
Sludge Centrifugation	Pilot plant in design stage Pilot plant in design stage	Irvine, Calif. Washington, D. C.
Sludge Filtration	Pilot scale studies in operation	Washington, D.C.
Sludge Hydrolysis	Exploratory studies--desk top	
Surface Spreading	Full-scale operation in progress Field evaluation unit in design stage Field evaluation unit in design stage	Canton, Ohio Morgantown, W. Va. Chicago, Ill.

Treatment ProcessDisposal Processes (Cont'd.)Wet OxidationScale

Full-scale operation in progress
 Full-scale operation in progress
 Full-scale operation in progress
 Full-scale operation in progress
 Field evaluation studies planned
 Experimental unit in operation

Location

Chicago, Ill.
 Wheeling, W. Va.
 Wausau, Wisc.
 Rye, N.Y.
 Santee, Calif.
 Rothschild, Wisc.

*Rejected: "Rejected" could be reconsidered on basis of new information.

Dr. Bartsch - Dr. Stephan

SECRETARY KLEIN: May we have the lights?

Now, if we may have Dr. Bartsch and Dr.

Stephan both on the rostrum, I'm sure that the conferees have questions to pose to both of them; and if you do pose a question, will you please, when you pose the question, advise to whom you are directing the question?

On my left?

MR. SINGLETON: No.

MR. PAESSLER: Mr. Chairman?

SECRETARY KLEIN: Yes, Mr. Paessler.

MR. PAESSLER: I would like to try to get a breakdown on the relative contributions --

SECRETARY KLEIN: To whom are you directing the question?

MR. PAESSLER: I guess to Dr. Bartsch -- the relative contribution of nutrients to the estuary from the metropolitan area and from the watershed above?

DR. BARTSCH: Mr. Paessler, from our conversation a little bit before this session began, I was alerted, so I brought with me a table.

MR. PAESSLER: Thank you.

DR. BARTSCH: This table is contained in a report which I believe you already have.

Dr. Bartsch - Dr. Stephan

It is the mysterious one that was lost this morning, and on Table II-3, as I read this, it indicates that of a total number of pounds of phosphate input reaching the lower Potomac area, and which comes to a sum of 93,600 pounds, 65,800 pounds originates in the Potomac River below Great Falls and 27,800 pounds originates above Great Falls.

I think the other question that you and I discussed briefly may be pertinent here. There is also a breakdown as to what proportion in each case comes from wastewater discharges as opposed to land and other sources.

MR. PAESSLER: Right.

DR. BARTSCH: And if we look at that, then we see that there is a difference in the watershed above Great Falls as compared with the area within the District, in which it looks to me as though roughly somewhere between a fourth and a third in the area upstream from Great Falls comes from land sources and the remainder from wastewater discharges, whereas in the cut at the metropolitan area or below Great Falls it looks as though somewhere approaching perhaps 90 percent comes from wastewater discharges and the remainder from diffused fashion off the land.

SECRETARY KLEIN: Mr. Jackson.

Dr. Bartsch - Dr. Stephan

MR. JACKSON: Dr. Bartsch, in your statement, on page 8, you state: "One therefore can expect that these waters will react accordingly and likely could still grow substantial algal crops even if the D. C. area inputs were to be substantially curtailed."

Do I understand then that there is a definite possibility that you might sustain algal blooms of a nuisance value even though all of the Washington Metropolitan Area sewage treatment plants remove substantially the phosphorus and nitrogen?

DR. BARTSCH: I will attempt to give you a direct answer, but first let me deviate in some indirect fashion, if I may.

I think one thing we have to recognize at the outset is that every body of water is going to grow some algae. I said in my statement that the density of the crops that a given body of water will grow, all other things being equal, is determined largely by the availability of the nutrients. So that means if you lop off 10 percent of the nutrients, you can lop off some amount of production; it may not be 10 percent, but it will be some amount.

If we come to the point where there is

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substantial reduction of nutrients in the waters in the Upper Potomac Estuary, we are going to have some corresponding reduction in the quantity of algae produced.

If we get to the point of reaching some of these critical numbers that I mentioned, then if this area functions like a lake -- and in my judgment it would function more like a lake than it would a river -- then we can expect that those numbers may not be too far out of line, and by the time we get to a level of, let's say, .01 mg/l of phosphorus, which is the critical number I mentioned, this simply means that for the average person the amount of algae that will be growing in a body of water will be found fairly tolerable.

If we add nutrients beyond this level, we are going to have some people who will find that level of production intolerable.

And there are obviously variations among people. I think my own point of view relative to the level we are to get to is to reach a level that all the people find the production levels tolerable. To me this means no blooms, if we can reach this point.

MR. JACKSON: Well, with the concentration, however, of phosphorus coming into the waters in the metro-

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politan area three times the critical level, would you expect this to happen even though sewage treatment plants remove all of their phosphorus?

DR. BARTSCH: I would expect that if we have the levels of phosphorus in the neighborhood of three times this critical level, there will be times when we have production of blooms of algae that many people will find objectionable. This is my judgment.

MR. JACKSON: Would you agree then that considering it in this light, that we should be very careful, implying that if high degrees of removal of phosphorus and nitrogen are obtained in this area, that we don't mislead people into believing that this will be the end or possibly would be the end of algal blooms in the estuary?

DR. BARTSCH: I think I would respond to that first by saying that at the present time if we do not take any steps to limit the availability of nutrients, we are going to have absolutely no improvement, and as the population increases -- and this morning I heard a projection to 7 million people -- well, I think it is obvious what is going to happen. We are going to reach a point where the production of algae is going to increase and increase up to some plateau, and I am not prepared to say

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what that plateau is, except that it would be a level which is limited by some factor other than phosphorus, for example.

I think at this stage of the game we need to be concerned not only with a program for today, but a program that will take into consideration the fact that there will be increasing population and that there are nutrients coming in from upstream, and I think we ought to set a goal of starting now to remove the availability of phosphorus in every way that it is possible to do so.

MR. JACKSON: Thank you very much.

SECRETARY KLEIN: Any further questions on my left?

Mr. Paessler.

MR. PAESSLER: Let me rephrase a question Mr. Jackson asked.

Assuming nothing is done about input to the estuary from upstream, and assuming nitrogen and phosphorus removal to the extent technologically possible in the metropolitan area, would it be a correct inference to say that the extent and severity of algal blooms might be reduced?

DR. BARTSCH: Yes, this would be my judgment.

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MR. PAESSLER: But can you quantitate that? Can you say how much less serious and how much improvement there would be?

DR. BARTSCH: Well, I would say that this would be a substantial improvement in view of this comparison between the loading coming in from the metropolitan area as opposed to what is coming in from upstream.

MR. PAESSLER: Thank you.

SECRETARY KLEIN: Yes, Mr. Hope.

MR. HOPE: Dr. Bartsch, one final question on this subject, as far as I am concerned.

I have heard the theory expressed that there may be other factors that relate to the development of unhappy levels of algal growth in surface waters, such as the presence of trace elements.

In connection with the research studies that you are supporting, are other possible means of control being considered, and are there any leads on the horizon at this time as it relates to the potential success of alternative methods of control?

DR. BARTSCH: I'm glad you asked me that question, because in my statement I said that there are four major approaches to the eutrophication problem and

I picked out what I considered to be the most likely to succeed. But if we look at some of the others -- for example, we have one major category which we call "mechanical control." It is a dismal thing, because in this category we contemplate harvesting algae in order to make the water look better. I will dismiss it simply by saying nobody in his right mind is willing to put up the dollars to do it.

I will go to the next major category which is chemical control, and one might in going back in history raise the question of whether some of what we suffer in the Potomac River Estuary now isn't because of the fact that this kind of control was practiced. I wasn't around when this happened, but I understand that sometime during World War II there were treatments of the rooted vegetation on the tidal flats with sodium arsonate to control the growth of plants, and perhaps part of the problem we have with algae stems from the fact that those plants are no longer there. The second category which contemplates the use of chemicals is also a dismal outlook as we think about it in relation to the Potomac Estuary, because if we were to use chemicals to destroy the algae, one of the things that we would be doing would be to stimulate the

biological system to recycle the nutrients a little bit faster than would happen otherwise, and when the nutrients are released from these algae of this generation, some other algae just pick them up and grow, and you might have some algae worse than the ones you started with.

We come to the third major category, which is to think about those ways in which we can make organisms work to destroy the algae. We know about biological warfare and we know about biological control within the entomologist's insect control field. We have seen a number of approaches within this general category.

One is to see if we can train viruses, and there are some now to do a virulent job, an effective job of knocking off the algal population. This is not available for general use at the present time. We are just now in a relationship with Syracuse University evaluating it on a pilot scale.

We can also think about bringing in some other kinds of organisms that will eat up the algae. I think this is also something we ought to look at. It is not a technology that is available at the present time.

So I come to Number 4 which I mentioned before, this ecological control, namely, changing the

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environment, and this is favorable because it is manipulable on a large scale. Within it, there are a number of things we can do. We have thought so far about limiting the availability of nutrients, those the most likely to succeed of some of the others, and if you are interested I will mention some of the others. If not, I will stop at this point.

MR. HOPE: I would like to hear them.

DR. BARTSCH: All right. One of the possibilities is related to the observation that in some cases it is not applicable to the Potomac Estuary. The production of algae may seem to be curtailed. While we can find some people who say, "This is what I have seen," we can also find other people who say that if we disturb the stratification in the lake it disturbs more algae than before, and we have an enigma.

We are in the process of trying to extricate ourselves from this enigma and we are setting up an almost full-scale test this summer to answer this kind of question.

We quickly find ourselves in the position of the drowning man who grasps for the straw, because we are even thinking about the possibility that there might

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be monolayer films developed to put on the surface of the water to reflect more of the light back into the atmosphere. This is on the basis that the amount of growth you get in another sense is determined in part by the solar energy that penetrates into the water. If we could reflect 10 percent of the light away, would it be possible therefore to decrease the production of algae by 10 percent? This is something to think about, and somewhere along the line we are going to have to answer this.

We can think about, as they did at Madison, Wisconsin, and the city of Seattle, not treating the sewage with tertiary treatment methods, but where it was possible to do so by diverting it away from the lake, and this has been a successful procedure in both cases. It makes the same point that it is the sewage which is the offender.

We can think about those special circumstances where a lake is situated geographically that we can grab off some low fertility water and divert it into a lake in order to dilute and flush out the high fertility water already present. We are in the process of setting up to do this.

These are some of the major things that are now available. It is difficult to think of any

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eutrophication problem in which the recycling of nutrients between the bottom sediments and the overlying water may not be an important factor, and so we are also looking at this, and we are fearful in the context of this, because many people come to us and say, "Let's dredge this lake and solve all our problems," that somebody is going to do this but not solve all their problems.

If you are interested, I can tell you why we take this point of view.

MR. HOPE: In one of the reports, some reference was made to the fact that the presence of an excessive turbidity in the Potomac water has in some respects had a salutary effect on the control of the growth of algae. If we should be successful in the elimination of turbidity, would we be back then in the unhappy situation of worrying about excessive algal growth? Again you have changed the ecology of the system, and the end result may be just as unhappy or worse than what we are experiencing at the present time.

DR. BARTSCH: Let me, in my response to that, strike out the adjective, "unhappy." I am not going to make a mental or moral or civic judgment with respect to this. But I think that one can speculate that certainly

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if the clarity of the water is increased as a result of the settling of the sediment there ought to be an increase in the production.

We have only to look at those places where this has already happened in order to verify that this is likely, such as the impoundments on the Missouri River, for example. The Missouri River is highly fertile water. When the water is being impounded, the sediment settles very quickly and then there are algal problems.

There are some other problems related to impounding water, and perhaps this is not the place to make this kind of pitch.

MR. HOPE: All right.

SECRETARY KLEIN: I think it would be wise if you stopped at that one, or we'll get in real deep.

On my right, Mr. Jackson?

MR. JACKSON: I think my question has been answered.

SECRETARY KLEIN: Mr. McKewen?

MR. McKEWEN: None.

SECRETARY KLEIN: Mr. Singleton?

MR. SINGLETON: No.

MR. JACKSON: Mr. Chairman, I have one question of Dr. Stephan.

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SECRETARY KLEIN: If I may, I would like to stay with Dr. Bartsch for just a minute.

MR. JACKSON: All right.

SECRETARY KLEIN: You say ten major chemical elements and six or seven trace elements. Could you give those to us, please?

DR. BARTSCH: Yes. I will also give them to you in such fashion that if you jot them down you will never forget them, because there is a little ditty that says, "See Hopkins Cafe Mighty Good." This is some advertising, and the "C" stands for carbon, the "H" for hydrogen, the "O" for oxygen, the "K" for potassium, the "N" for nitrogen, "S" for sulphur, "M" for magnesium and "Fe" for iron.

SECRETARY KLEIN: And the trace elements?

DR. BARTSCH: You may get me at a disadvantage. I never paid too much attention to them because they are so minute, but among them we have zinc and copper and manganese and molybdenum and cobalt, and perhaps one or two others.

SECRETARY KLEIN: What happens if you get too much copper?

DR. BARTSCH: If we get too much copper, you kill the algae.

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SECRETARY KLEIN: That is the copper sulphate they tried in Fox Lake in my area.

By the way, in this harvesting Detroit Lakes, they are going to show me a new machine they've got on August 18th.

DR. BARTSCH: You'll be amazed. It will feed at the rate of about 12 tons per minute.

SECRETARY KLEIN: I am very much impressed with the proposition.

You say we really don't know all the details and the results yet from our scientific research, and then you say we're going to go slow. Is that about right?

DR. BARTSCH: I would say yes, that's about right, with one addition --

SECRETARY KLEIN: Not that you are going to go slow on scientific research, but go slow in implementing them until you know all the effects?

DR. BARTSCH: Yes. I am looking forward to going much, much faster with the research than we have done so far. But in direct response to what you have said, I think we should not be blinded by the fact that we know many things now, and, as I said before, this matter of

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the relationships in the main between the availability of nutrients and the production of algae we have known for 130 years. I think it's time we say, "Well, let's put to work what we know," and we also know that if we don't curtail the availability of nutrients in the Potomac River Estuary we are going to come back here, as the lady from the League of Women Voters said this morning, at some future date with an estuary no better than we have at the present time and perhaps worse.

SECRETARY KLEIN: Or worse. The problem is although we knew this maybe 130 years ago, that until four or five years ago nobody really was concerned with pollution and its results. It has only been the tremendous upsurge in population and the tremendous increase of industry's use that brings it home to us, and now, as far as I am concerned, pollution is going to cause us as much trouble in water supply as the arid condition is causing in the southwest. We are running short on water supply in the midwest and east as well, and pollution is the cause.

DR. BARTSCH: I agree with you completely.

SECRETARY KLEIN: Now we'll go a little bit further. We have been talking right along about the

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pollution problem from the wastewater treatment in the Washington area and we are back again at, I think, the second largest pollution cause and that is farm runoff.

This is the one that brings too much fertility into the region to begin with; is that correct? We get fertilizers off of farm lands and upstream applications and the like?

DR. BARTSCH: Yes, this is an area of input which has not really been looked at very hard in the past. There have been one or two who have looked at it. We are reaching the point where it appears--and I understand the Department of Agriculture has been working in this area assessing the problem--that it is not so much the cultivated land, but the feedlots and the barnyards which are the major sources of input of nitrogen and phosphorus. This is the agricultural aspect of the problem, as I understand it.

SECRETARY KLEIN: I did not get it so, because in a lot of areas that I have seen in the midwest they don't have too many feedlots and they are getting it off of farm lands, and they are getting a great deal of this fertilizer by leaching, not just from runoff above ground but through the normal channels underground.

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DR. BARTSCH: Yes, this is true. It has been observed in Wisconsin, for example, in connection with Lake Mendota, that it even makes a difference when during the year fertilizers are applied by the farmer to his land. But I think when you look at this, this is a sizable input, but by contrast for the area concerned the feedlot and the barnyard are even worse.

SECRETARY KLEIN: I will agree with you as to the area concerned, but as to the total input, we can't get the controls on these small areas such as feedlots and barnyards. We can't get to them because they are small areas, but how do you get to control these large areas where each large piece of acreage puts in just minute quantities and you don't realize it until it has accumulated downstream?

DR. BARTSCH: Well, I think this is a real difficult problem. I think at this point in time we could only say that, at least as far as I know, we have no technology even to test in terms of its effectiveness, and it points to the fact that here is an area in which we need some work in order to develop a technology.

While it may sound far-fetched with this group of people, I think that somewhere along the line,

one generation or two or three from now we are going to have to develop some procedure for picking up these sources of nutrients that come in diffused fashion now off the land, bring them to a point source and do something with them.

SECRETARY KLEIN: May I ask you one more question? As we have this algae and then we have added some more fertilizer to it -- nutrient pollution you call it -- do we have an arithmetical growth of algae or do we have a geometric growth? Does it grow 1, 2, 3, 4, or 1, 2, 4, 8, 16?

DR. BARTSCH: Well, this is a difficult question to answer because there are a number of answers within the major answer, and if you look simply at the mechanics by which algae reproduces itself, it is a fairly unexciting thing in which they simply, many of them --

SECRETARY KLEIN: No sex involved (laughter).

DR. BARTSCH: Dr. Hetling said I should add "in today's context," but simply they increase in numbers in a geometric progression. But to simply say that as you add twice the nutrients you get twice the amount of algae, it may not quite be this way, because biological systems are fairly fickle and they don't always

do the things you expect them to do.

We can say in general, however, that as you increase the nutrients up to some kind of level there will be an increase in a proportion to the increase of nutrient availability.

When you reach the point where some other factor comes into operation -- let us say, for example, the penetration of light through the system -- as the algae grows the water becomes green, it looks bad and the light cannot penetrate very far through the water, and so the volume of the estuary or the volume of the lake that participates in this job of making more algae is shallower and shallower and shallower.

SECRETARY KLEIN: I might say then the gist of your statement today is that we should get to controlling the wastewater discharges in the Washington, D. C. area from the populated areas, and then we should also at the same time get started on cutting down the fertilizer input from the upper reaches of the Potomac. In other words, we've got to cut the fertilizer input in both places.

DR. BARTSCH: Mr. Chairman, I am pleased that my message has gotten across precisely as I intended.

SECRETARY KLEIN: Thank you. One more

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question over here. Mr. Jackson.

MR. JACKSON: I have a question of Dr. Stephan. What removal of nitrogen is achieved in advanced waste treatment for phosphorus only? Dave, could you give us some idea of what that might be?

DR. STEPHAN: I am not sure of your question.

MR. JACKSON: Assuming that you treated for phosphorus removal only, would you expect to get any nitrogen removal as a result of that?

DR. STEPHAN: If you are referring specifically to utilizing the tertiary chemical flocculation process following activated sludge, you would not expect to achieve any significant removal of nitrogen throughout that tertiary process.

Now, the total system will knock out perhaps 50 percent of the nitrogen in the raw wastes, but you will have achieved none of that through the tertiary process. However, as I am sure you are quite aware, much of the cost involved in the process is with overcoming the buffer capacity of the stream.

So now you effectively remove the phosphorus, and having gotten that highly alkaline condition,

those are exactly the conditions, as you know, under which it is most economical to strip out the nitrogen in the form of ammonia, so the two in a sense go hand in hand, but unless you have that stripping process in there, no, you won't touch the nitrogen.

MR. JACKSON: Thank you.

DR. STEPHAN: Mr. Chairman, I wonder if I might add one further answer to a question that you had asked earlier about the runoff?

SECRETARY KLEIN: Yes.

DR. STEPHAN: I wouldn't like the group to have the impression that nothing can be done with regard to the minimization of nutrient runoff from cultivated lands and fields. Of course, good agricultural practices now exist and have existed for some years to maximize the utilization of fertilizer in the growing crops, and these same techniques to some degree, of course, obviously minimize the phosphorus that is unused by being washed away and stripped off and leached into the stream.

There are also practices with regard to proper farming management, such as the question of the contour system and so on, to minimize the amount of carry-off of fertilizers into the stream, so there are things

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that can be done. I certainly don't agree that we don't have the answer on that one that we would like to have.

SECRETARY KLEIN: I will agree with you on that, and I think that one of the tests that was run said that fall plowing contributed 50 percent of the siltation problems that we get, and if we could get the farmer to stop plowing in the fall, and it doesn't do much good to do it, why, we would get rid of a good many of these problems we already have, and the problem you are going to have is reaching all of these individual farmers.

Yes, Mr. Paessler?

MR. PAESSLER: I have one more question of Dr. Stephan.

Obviously, for a plant of less than 100 million gallons a day capacity the unit costs go up. Do you have any figures to relate this to, say, 50 or 25 million and how much will the unit costs go up?

DR. STEPHAN: Yes, we have these figures. I will be happy to give you a document which relates to that.

MR. PAESSLER: Thank you very much.

DR. STEPHAN: I have a copy here.

MR. HOPE: I would like to ask a question.

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SECRETARY KLEIN: Yes. I think we are all finished with you for the time being, but don't run away, Dr. Bartsch. Dr. Stephan is now on the stand.

Mr. Hope?

MR. HOPE: Dr. Stephan, I think I was somewhat impressed by the analogy that was developed by Dr. Hetling earlier this morning about the checkbook and the credits and debits.

You have made a very excellent presentation on what it will cost to do certain things. Those of us who have to go out and sell someone on the idea and have to find the dollars to pay for the costs that are involved are going to be asked, "What will I get in the way of a return on my investment?"

Is there any possibility of our coming up with some cost benefit relationships here as it relates to what will accrue to those who are paying the bill as a result of doing all the things that we have been talking about this morning and so far this afternoon, so that they could be presented to the lay individual in meaningful terms and he can better understand what his contribution is going to buy?

DR. STEPHAN: Mr. Hope, initially I think

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I am not properly qualified to answer that question very intelligently. I am not a social scientist. My field does not relate to attitudes, surveys and the type of cost benefit analysis which you are referring to.

There is a considerable amount of work under way in this country, primarily in the universities, relating to cost benefit values associated with pollution control.

I think honestly probably the major cost benefit here, at least in this particular scene, will relate to what the decisions of the conferees are here. The costs I think have been presented in general. I know the District of Columbia has considerably more detailed cost projections for the particular facilities. I think it is going to be a matter of, in this sense, not waiting for the research to be done to project what the benefits are going to be, but actually determining what the outcome of this conference is as to whether or not the benefits to be derived in your judgment are worth the costs that are presented.

MR. STEIN: Mr. Hope, we had a discussion of that at the American Civil Engineers Convention in New Orleans recently where we discussed the applicability of

the cost benefit concept to the subject of water pollution control and what we are supposed to do. I think the majority of the panel at least representing the Federal Government and several States agreed that the cost benefit theory was not exactly applicable to this. However, the industry man on the panel did think that the cost benefit theory should be applicable.

Generally speaking, where we have a choice-- and I am not talking in terms of cost benefit which we do in our everyday life--whether you take an airplane or a train or a bus to New York from here, you always apply this rough cost benefit to your own judgment.

The cost benefit theory works in an area traditionally that is used by the Corps of Engineers for dams or dredging, or the Bureau of Reclamation where you are going to determine which of the projects you are going to engage in, where there may be 10 or 15 applicable projects and you want to set a priority or you can only pick three or four and you will see which one will give you the most benefit in relation to the costs, and you go ahead.

But in pollution control, if you are thinking in terms of a clean river, and the results of many of

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the effects of the clean river are intangible results, I think it is a question of whether we want to pay the cost for that clean river. I think the analysis that Dr. Stephan used before in relating this to the cost that you would pay for a telephone service or the cost you would pay for any other utility service, such as gas or electricity, whether you are ready to pay that for clean water was good. And I think the judgment of most of the people in the field has been that compared to the other services we have gotten, that the social cost for paying for clean water is just a fraction of what we are paying for these other services. And we have not even begun to approach the kind of costs we pay for the other.

When we talk in terms of whether you are going to have a clean river or not or you are going to make an analysis and say as a result of the cost benefits we are not going to do it, you are going to wind up with a polluted river, so that this cost benefit approach in this social context may not be too meaningful.

SECRETARY KLEIN: Along that line, if I may carry forward Mr. Murray Stein's thinking, the FWPCA at my suggestion is carrying forward the proposition of whether, after you pollute a river and don't clean it up,

you then have diminishing returns from that area because you lose industry and lose population that will move to some other area because they don't have the water that is available for use.

We don't know yet. We are taking a look at some of them that have had real pollution problems and don't seem to be growing, and we don't know whether this is the cause or not, and also at some of them that are growing rapidly because they do have good water available, and good practices.

Mr. Hope.

MR. HOPE: I would hope, Mr. Chairman, just in conclusion that my question was not misunderstood. Once again, I think that the professionals in the field need the kind of arguments and need the kind of evidence so that we can better convince the lay public of the need to do certain things that I would agree need to be done.

SECRETARY KLEIN: Mr. Jackson.

MR. JACKSON: Mr. Chairman, if I might just add though, in connection with the costs which Dr. Stephan has mentioned, these costs apply to waste treatment only. They do not include the cost that it might take to treat combined overflows or stormwater, the costs

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of which possibly could be equally big in terms of financial investment. These costs are not added.

So to get the kind of river, though, that I think we are speaking of when we say "clean," and I guess I have to refer to that initial definition that Dr. Bartsch made just a moment ago, then I think all costs are involved in Dr. Stephan's presentation.

SECRETARY KLEIN: Mr. McKee, did you have any questions?

MR. McKEE: No questions, Mr. Chairman.

SECRETARY KLEIN: Mr. McKewen?

MR. McKEWEN: No.

SECRETARY KLEIN: Mr. Johnson?

MR. JOHNSON: No.

SECRETARY KLEIN: I want to know--and I think this is the ultimate question--what happens to the Potomac if you put in the Blue Plains pilot plants on all the sewage treatment plants in the area, and then you can tie in some cleanup of your fertility from upstream from your runoff of the upper Potomac? What happens then to this area which we have likened to a lake if we do that?

Dr. Bartsch or Dr. Stephan or both of you, what happens if you do it? Now, this is the ultimate

question.

DR. STEPHAN: I am going to beg off on a complete answer and refer you to Dr. Bartsch for a more complete answer. But in terms of what happens, the projections which Dr. Hetling described this morning with regard to DO, dissolved oxygen, would be achieved. In other words, the dissolved oxygen would meet the water quality standards which have been set and agreed upon by the States involved.

The other water quality parameters that are involved in pollution that obviously in this area relate to the eutrophication or algal growth would be ameliorated to an unknown degree, based upon what detailed answer Dr. Bartsch gave you earlier, but would be reduced.

The discharge of bacteria to the stream would be substantially reduced, and I think perhaps on the model Dr. Hetling might be able to give you some quantitative figures as to what degree.

Unfortunately, I cannot say whether that would make the water swimmable or not, but on these three figures we would have the sort of quantitative improvements.

DR. BARTSCH: With respect to the algal production aspect of the answer, I would say certainly I

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agree with what Dr. Stephan has said. Any incremental decrease in the availability of nutrients or the nutrient input is going to decrease the general productivity of the estuary.

This means that blooms are either going to be milder in nature or there is going to be a longer gap of time in which we do not have them, and I would anticipate with time that conditions would gradually improve. I don't think that this is going to happen overnight. I think there are some nutrients built into the system that may have to be carried away, and I would hope also that as we go on in time we will regenerate new technologies all the time, so that while we are talking about curtailing some 80 percent of the sources now, we may ultimately reach the point where we are controlling the input from all the sources, and if we do that, maybe there is prospect and promise of going back to the kind of river that George Washington saw.

I think this is a goal and I think we ought to look forward to it.

SECRETARY KLEIN: In other words, you do think that it is possible to get to it. This is the answer.

Dr. Bartsch - Dr. Stephan

You can't sell an expensive program to the people unless you can show a positive answer on it. It isn't enough to say you are controlling the input. What can you do to the Potomac if we do all these things?

DR. BARTSCH: Yes. I am an optimist and I would view that we are going to reach the point in the production of materials that this is a usable and acceptable body of water.

SECRETARY KLEIN: Thank you. Are there any further questions of either Dr. Bartsch or Dr. Stephan?

MR. JACKSON: Mr. Chairman, may I ask Dr. Bartsch a question?

SECRETARY KLEIN: Surely.

MR. JACKSON: You speak of possibly carrying away nutrients that might be here. Are you referring to the sedimentation?

DR. BARTSCH: I was thinking primarily of the fact that the 1954 survey, of which I was a party member of a small party, incidentally -- one of the things I did was to probe down to the bottom sediments in the lake with very crude equipment at that time, and I found that some of the sediments in the metropolitan area sometimes were deeper than the roughly 12-foot tubes that I

had. That means to me that one ought to look at this sediment bed in the bottom of the estuary. Perhaps some of our FWPCA people have done this, and if they have, I have not seen the results, relative to the question of whether or not recycling of nutrients from the sediments into the overlying water on some continuing basis usually is not significant. If it is significant, why, then this is going to have to be dissipated. Maybe it is dissipated in one year, depending upon what kind of flood pictures you have, or it may be something that lasts longer than that.

This is what I meant.

SECRETARY KLEIN: Anything further, gentlemen?

MR. JOHNSON: Mr. Chairman, I would like to ask Dr. Bartsch a question.

SECRETARY KLEIN: Yes, Mr. Johnson.

MR. JOHNSON: On this upstream source of phosphate load, do you have any data on the diversion of that load to the water supply intakes and consequently through the waste treatment plants?

DR. BARTSCH: No, I do not. I would presume that someone among our technical people must have

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some information on the gallonage of water which is so diverted, and this could be tallied up in terms of what concentrations are present in it when it is again sent back to the estuary, but I do not have that information.

SECRETARY KLEIN: In behalf of the conferees and everybody who is here, I would like to congratulate Dr. Hetling, Dr. Bartsch and Dr. Stephan for a marvelous presentation in answering the good questions this afternoon. I think the results have been tremendous in their presentations. Thank you very much.

I would like at this time to present to you the Commissioner of the Federal Water Pollution Control Administration, Mr. David Dominick.

MR. DOMINICK: Thank you, Mr. Chairman.
I am very happy to be here.

SECRETARY KLEIN: We would like to go on with several others before we wind up this afternoon. I have a lady here from the Canoe Cruisers Association of Washington, D. C., Anna Marie Herfindahl.

And then I think we will wind up as quickly as possible.

Miss Herfindahl.

STATEMENT OF
MISS ANNA MARIE HERFINDAHL
CANOE CRUISERS ASSOCIATION
OF WASHINGTON, D. C.

MISS HERFINDAHL: Mr. Chairman, Conferees,
and Ladies and Gentlemen:

My name is Anna Marie Herfindahl. I am a member of the Canoe Cruisers Association of Washington, D. C. Conservation Committee. CCA is an active white water canoeing club interested in the preservation of rivers and their historical and esthetic environments and in control of stream pollution in the Potomac Basin.

The purpose of this statement is not to discuss the technicalities of water quality control but rather to suggest the water quality situation toward which we should be working and some general lines of approach to it. The Canoe Cruisers Association is an organization concerned with the conservational and recreational aspects of the river, but it is also very much aware that there are other uses to which the river is put which must be reckoned with.

With respect to recreational use, the main

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opportunities for improvement involve the part of the river above the estuary together with its tributaries, although the area between Little Falls and the Blue Plains plant is very heavily used for recreation. Some of these stretches are especially well suited to meet several types of recreational demands. Others are visited by many people because of their historical importance and interest. Still others are used as sources of city water supply. In each of these parts of the river system, the water should be maintained at a high level of quality with respect to oxygen level, sediment and inorganic wastes.

These important stretches of the river include, in part, the North Fork of the South Branch, the South Branch of the Potomac, the Cacapon River, Antietam Creek, Goose Creek, the main stem of the Potomac from Paw Paw Bends to Great Cacapon, the area of the confluence of the Shenandoah and the Potomac at Harper's Ferry, most of the Shenandoah, and the whole of the Potomac from White's Ferry to the Blue Plains plant. These areas include spectacular canyons, groves of hemlock and pine, rock formations of a spectacular nature, and inlets at the ends of which are small water falls and quiet pools. Some are famous for the quality of their fishing. Antietam Creek flows

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through portions of Civil War battlefields and should be preserved in good condition in the national interest.

In the immediate metropolitan area it certainly seems sensible to consider the cleaning up of Rock Creek as a matter of high priority in view of its potential as a recreational stream in an area of high population density.

It would be unrealistic to aim at maintaining every part of the whole Potomac system at a uniformly high standard of quality. Instead, the following questions should be asked: What are the most important uses of the water in given areas? How do we want to use it or how can we combine uses? How can we go about establishing standards or other devices which would permit these uses?

There is ample evidence to support the allegation that we have been far from successful in the maintenance of water quality even with respect to existing standards. Some of the possible reasons that should be looked into are the adequacy of the staffs of control agencies and treatment plants, including their training and level of pay. Beyond this, however, the increasing pressure of often conflicting demands on this water resource will make it increasingly advisable to deal with

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water quality problems on a regional basis. That is, we need to think in terms of the best mix of measures for quality control for satisfying the different demands on the water resource at different points on the streams of the system. The tools for control include much more than uniform minimum standards, although we do believe that the minimum 96 percent BOD removal standards for treatment plants is feasible and desirable. Standards do not have to be the same in all places, and almost certainly should not be. Nor need they be the same at all seasons of the year or at all levels of flow. In addition to standards, it is obvious that careful regulation of the location of new pollution producing activities could make an important contribution to the economical maintenance of water quality.

Beyond these, however, there are methods of control, such as charges based on quantity and types of effluent coupled with system-wide design of the treatment network, that we haven't begun to think about in this basin but which we may find to be desirable in the future.

I would have to rewrite that because of the talks this afternoon.

We welcome the opportunity to participate

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in this examination of the water quality problem in the Potomac Basin. Meetings such as this one should continue to be held in the future so we can make some progress in improvement of water quality and not merely keep pace with the growing load of pollution.

Thank you.

SECRETARY KLEIN: Thank you very much.

To all of you who are still present and to those who have presented papers here today and have answered our questions, I say thank you.

I think we have done a very good job today. We have gone into a lot of facts and figures and have already come out with some conclusions.

I thank my fellow conferees for asking intelligent questions and getting at the basis of some of these talks where we were left outside for a few minutes by mathematical formula.

May I say at this time that our posteriors have probably taken everything they can and are dulling the other end of our systems by sitting too long, and I think we will recess until 9:30 tomorrow morning.

Thank you very much.

(Whereupon, at 4:00 p.m., a recess was taken until Thursday, April 3, 1969, at 9:00 a.m.)